ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. LV. No. 11. 220 Broadway, New York, March 15, 1906.

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FAST PASSENGER LOCOMOTIVE FOR HEAVY SERVICE; CHICAGO, MILWAUKEE & ST. PAUL RY.

Some of the through trains of the Chicago, Milwaukee & St. Paul Railway between Chicago and Milwaukee are very heavy owing to the fact that they are composed of cars for (or from) different divisions diverging at Milwaukee, but which are run as solid trains between that point and Chicago. There are usually from 12 to 14 cars, sometimes as many as 15, and many of these are heavy sleeping cars. Some trouble has been experienced in handling these heavy trains at the high speeds necessary to keep the schedule with the four-cylinder Vauclain compound engines of the Atlantic type (4-4-2), and a special design was made for a six-coupled engine of the Pacific type (4-6-2). The engine was designed by Mr. J. F. De Voy, Mechanical Engineer, under the direction of Mr. A. E. Manchester, Superintendent of Motive Power, and was built early in 1905 at the company's shops at West Milwaukee. It is of interest to note that this company now builds all its locomotives at its own shops.

A comparison of this engine with three other large engines of the same type is given in the accompanying table.

This engine has now been in regular service for some months and has handled the trains without difficulty, even making up time lost by signal stops, etc., and attaining speeds as high as 70 miles an hour with a load of 750 tons behind the tender. Maximum speeds, however, are of less importance than ability to maintain the schedule with heavy trains and under adverse conditions of weather.

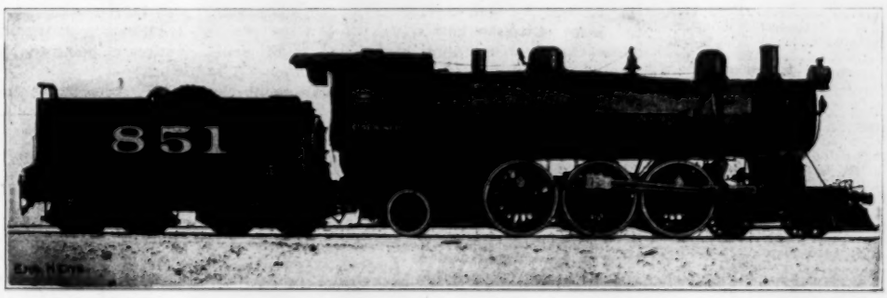


FIG. 1. FAST PASSENGER LOCOMOTIVE FOR HEAVY SERVICE: CHICAGO, MILWAUKEE & ST. PAUL RY.

A. E. Manchester, Superintendent of Motive Power. J. F. De Voy, Mechanical Engineer.

The engine is simple, with large cylinders and large boiler capacity and has piston valves operated by the Stephenson link motion. The spring rigging is equalized from the front driving axle to the trailing truck axle. The front driving axle has the springs over the boxes, but the others have yokes seated on the boxes and carrying links for inverted springs seated under the top bar of the frame; behind the rear driving boxes the links carry a transverse bar in front of the ashpan, this bar supporting long equalizing levers whose rear ends are suspended by links from springs over the truck axle boxes. The main frames are very heavy and have bolts put through spacing sleeves between the feet of the pedestals; at the cylinder casting there is a single heavy bar passing behind the cylinder and under the valve chamber, while at the rear there is a deep flat slab carrying the firebox. The frame is all forged, however, and is one piece from end to end, although plate frames are now frequently used for the rear portion in engines having trailing trucks. The driving wheels are placed as close together as possible and very close to the truck. These wheels and the truck wheels are 53¼ ins. back to back, while the trailing wheels are 53⅛ ins. back to back. The dome (with whistle at the side) is placed on the wagon top, in front of the tube sheet, and behind it is a special fitting for the safety valves. The sandbox is placed at the front end of the boiler barrel. While the engine has a number of special features in detail, it has three particularly important features: the cylinder proportions, the firebox and the trailing truck.

The cylinders are of large diameter and are so proportioned as to obtain a high starting power equal to that of four-cylinder Vauclain compounds when using live steam in the low-pressure cylinders. In this way the engine is able to start its heavy trains easily and to accelerate the speed rapidly.

For some years past there has been a very general tendency towards the adoption of the wide firebox, but the experience with this type of firebox on the Chicago, Milwaukee & St. Paul Railway has not been satisfactory, and in all the new engines the narrow firebox has been reverted to. The main trouble with the wide firebox has been the short life and the excessive amount of repairs required, both to the sheets and to the staying. In some cases the sheets of the wide fireboxes have lasted only about 12 to 18 months, where narrow fireboxes on similar engines on the same division have lasted about eight years. In the new engine under consideration the width is only 3 ft. 5⅛ ins., and in order to give the necessary grate area a length of 10 ft. 5⅛ ins. is given. It has been claimed that 9 ft. is the greatest length of grate that can be properly fired without special care (which may not always be given) on the part of the fireman, but there is said to be no trouble in this respect. There is one firedoor, 18 ins. diameter. The firebox is also unusually deep, 6 ft. 6 ins. from crown sheet to grate at the front end; the purpose of this is to compensate for the narrow width in order to give ample space for the mixture and combustion of the furnace gases, and this is assisted by a long firebrick arch supported on water tubes. There are nine 2-in. combustion tubes or hollow staybolts admitting air to the firebox. It has a radial-stay crown sheet, and the back head and front water leg are inclined. The fuel is bituminous coal.

The boiler is of the extended wagon-top type and has tubes of the same length as those in the Atlantic or four-coupled engines. The smokebox is of unusual length, 7 ft. 3 ins. from the tube sheet, which is set back within the barrel; this is to avoid excessive draft on the fire and to prevent any choking with cinders. A petticoat pipe or draft pipe is fitted between the exhaust nozzle and the smokestack.

The trailing truck is peculiar in that there is no swiveling frame or radius bar, and the only movement of the axle is lateral, the extreme movement to either side being 2½ ins. The pedestals on each side are formed in one piece with a connecting transverse web, and the axle boxes are formed in a single steel casting, upon which rests a cross-brace under the frames. Over each box are two rollers, 2 × 12 ins., of hardened steel, fitting grooves in the top surface of the box and the bottom surface of the cross-brace. The arrangement is similar to that of the Barber roller-bearing freight truck which is used very extensively on this and other roads. The load upon the truck is about 34,000 lbs., or 8,500 lbs. per roller. The grooves or concave seats for the rollers have an elliptical section and are so shaped as to prevent any lateral motion of the truck on tangents, but to permit of easy and sufficient motion when passing around curves. This truck is the invention of Mr. J. F. De Voy, Mechanical Engineer.

The leading dimensions of this interesting engine are given below in our standard form:

Dimensions of Passenger Locomotive (4-6-2 type): Chicago, Milwaukee & St. Paul Ry.

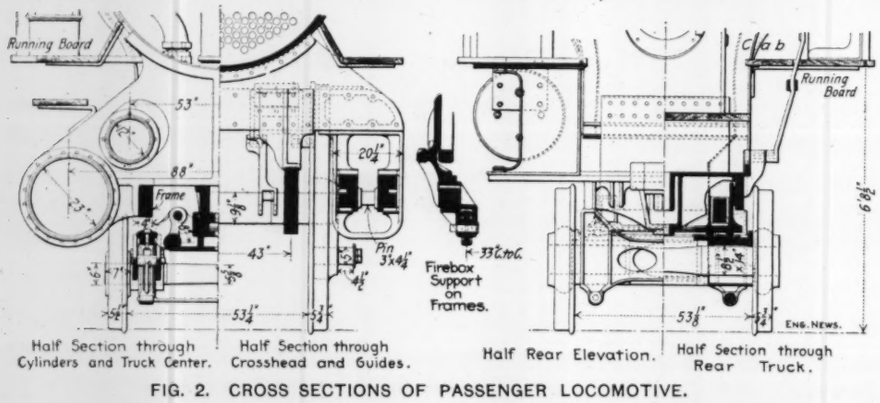
RUNNING GEAR:	
Driving wheels (6), diameter	6 ft. 1 in.
Truck wheels (4), diameter	2 ft. 9 ins.
Trailing wheels (2), diameter	3 ft. 6 ins.
Tender wheels (8), diameter	3 ft. 2 ins.
Driving and trailing wheel centers	Cast steel.
Truck and tender wheels	Steel tired.
Driving-wheel tires secured	By shrinkage.
Engine truck	Swing center
Journals, driving axles	9 × 12 ins.
WHEELBASE.—Driving, 12 ft. 6 ins.; Truck, 6 ft. 4 ins.	
Total engine	32 ft. 5 ins.
Tender, 18 ft. 1 in.; Engine and tender	50 ft. 11½ ins.
Distance, truck-pin to 1st driving axle	7 ft. 9 ins.
Distance rear driv. axle to trailing axle	9 ft. 0 ins.
Wheels having blind tires	None.
Length over all	70 ft. 6 ins.
WEIGHT IN WORKING ORDER:	
On driving wheels, 130,500 lbs.; on truck	44,250 lbs.
On trailing wheels	34,000 lbs.
Engine, total	208,750 lbs.
Tender, empty, 48,267 lbs.; loaded	125,600 lbs.
Water in tank	58,000 lbs.
Coal on tender	19,600 lbs.
Counterbalance	Davis counterbalance.
Weight of piston, 160 lbs.; piston rod	400 lbs

TABLE I.—DIMENSIONS OF LARGE LOCOMOTIVES OF THE 4-6-2 TYPE.

	Chi. Mil. & St. Paul Ry.	Union Pacific Ry.	Chicago & Alton Ry.	Erie Ry.*
Driving wheels	6 ft. 1 in.	6 ft. 5 ins.	6 ft. 8 ins.	6 ft. 2 ins.
Weight, on drivers	130,500 lbs.	142,000 lbs.	141,700 lbs.	149,000 lbs.
Weight, total	208,000 "	222,000 "	219,000 "	230,500 "
Cylinders	23 x 26 ins.	22 x 28 ins.	22 x 28 ins.	22½ x 26 ins.
Boiler, diameter	5 ft. 10¼ ins.	5 ft. 10 ins.	5 ft. 10 ins.	6 ft. 2⅛ ins.
Working pressure	200 lbs.	200 lbs.	220 lbs.	200 lbs.
Firebox	3¼ x 10½ ft.	5½ x 9 ft.	6 x 9 ft.	6¼ x 9 ft.
Tubes, No.	363	245	328	195
Tubes, length	16 ft. 6 in.	20 ft.	20 ft.	20 ft.
Heat. surf.; tubes	3136 sq. ft.	2874 sq. ft.	3848 sq. ft.	3119 sq. ft.
Heat. surf.; total	3381 "	3053 "	4078 "	3321 "
Grate area	86 "	49½ "	54 "	56½ "
Builder	Ry. Co.'s Shops	Baldwin Loco. W'ks.	Baldwin Loco. W'ks.	Am. Loco. Co.
In "Engineering News"	This issue.	Oct. 6, 1904	May 28, 1903	.....

*The Erie Ry. engine is equipped with a Cole superheater having 763 sq. ft. of heating surface.

Weight of crosshead, 345 lbs.; main rod, 885 lbs.; side rod .....566 lbs.
CYLINDERS .....Two.
Diameter and stroke .....23 x 26 ins.
Distance c. to c.....7 ft. 4 ins.
Cubic contents of all cylinders.....12.5 cu. ft.
Crosshead and guides.
Four-bar guides, wrist-pin cast in crosshead.
Connecting rod, length between centers....9 ft. 7 ins.
Side rods .....Solid ends.



Half Section through Cylinders and Truck Center. Half Section through Crosshead and Guides. Half Rear Elevation. Half Section through Rear Truck.

FIG. 2. CROSS SECTIONS OF PASSENGER LOCOMOTIVE.

VALVE GEAR.—Type.....Link.
Ports, steam, 1⅝ ins.; Ports, exhaust.....2½ ins.
Bridges, width, 1⅛ ins.; Eccentrics, throw.....6 ins.
Slide valves, style, Piston; diameter.....12 ins.
Slide valves, max. travel, 6 ins.; inside lap, 1 in.; outside lap (negative) .....¼-in.
Radius of links.....4 ft. 5 ins.
BOILER.—Type .....Extended wagon-top.
Barrel, diam. inside smallest ring .....5 ft. 10½ ins.
Dome, diameter .....2 ft. 7½ ins.
Thickness, barrel plates, ¾, ⅝-in.; smokebox tube-plate .....½-in.
Horizontal seams .....Sextuple riveted.
Circumferential seams .....Double riveted.
Butt joints; Rivets, diameter .....1⅛ ins.
Height, rail to center line.....9 ft 5 ins.
Smokebox, length (including extension)....7 ft. 3 ins.
Spark arresting device.....Deflector and wire netting.
Working steam pressure .....200 lbs.
FIREBOX.—Type .....Narrow, radial-stay.
Length inside, 10 ft. 5⅛ ins.; width inside.3 ft. 5½ ins.
Depth at front, 6 ft. 6 ins.; depth at back.5 ft. 10½ ins.
Thickness, side plates, 5/16-in.; back plate.....⅝-in.
Thickness, crown plate, ⅜-in.; tube plate.....½-in.
Crown stays .....Radial, 1-in.
Fire-brick arch.....Carried by three 3-in. water tubes.
Water spaces, width at front, 4 to 6 ins.; at back, 3½ to 6½ ins.; at sides.....3½ ins.
TUBES.—Number 363
Diameter, outside .....2 ins.
Length over tube plates.....16 ft. 6 ins.
HEATING SURFACE AND GRATE AREA:
Heating surface, tubes (interior area)...3,136.00 sq. ft.
Heating surface, firebox .....245.60 sq. ft.
Heating surface, total .....3,381.60 sq. ft.
Grate area .....35.84 sq. ft.
Ratio of total heating surface to grate area .....1 to 94.35
Ratio of interior tube area to firebox heating surface .....1 to 12.77
Total heat. surface to 1 cu. ft. cyl. vol...270.53 sq. ft.
Firebox heat. surf. to 1 cu. ft. of cyl. vol.. 19.65 sq. ft.
Tube heat. surface to 1 cu. ft. of cyl. vol..250.88 sq. ft.
Grate area to 1 cu. ft. of cyl. vol..... 2.86 sq. ft.
MISCELLANEOUS:
Exhaust nozzle, distance below center line of boiler .....2⅝ ins.
Smokestack, diameter at top and base... 1 ft. 6 ins.
Smokestack, height above smokebox..... 2 ft. 6½ ins.
Smokestack, height above rail.....15 ft. 0 ins.
Capacity of tender tank.....7,000 gallons.
Capacity of coal space.....10 tons.
Total tractive force with effective pressure equal to 85% of boiler pressure.....32,475
Ratio of tractive force to weight on driving wheels 4.37

MOUNTAIN ROAD CONSTRUCTION IN IDAHO.

By E. B. Darlington.*

The literature of mountain wagon road construction is exceedingly meager. One reason for this is no doubt the fact that it has been too often the practice in this country to build such highways without engineering advice or supervision, and as a consequence but few roads of a noteworthy character have been built. That the go-as-you-please methods of construction have been unfortunate is evidenced by the present miserable condition of a great many of the mountain roads of the West, on which apparently no attention has been paid to grade, alinement, cross-section or drainage, the paramount object seeming to be, frequently, to connect two points by the shortest route, regardless of the differences in elevation, It should therefore be of interest to the readers of Engineering News to know that the State of Idaho has inaugurated a system of mountain road building based on sound principles and planned along systematic lines. The numerous and increasing demands upon the Legislature for State aid in building roads for the development of the mines and the popular sentiment in regard to such assistance finally crystallized in a measure authorizing a bond issue and a special tax to provide funds and the organization of a commission to administer the funds.

It thus came about that the session of 1905 created the Idaho Intermountain Wagon Road Commission and authorized the issuance of bonds to the amount of $50,000, the funds from the sale of the bonds to be used in the construction of a system of wagon roads and trails designed to make the developed and undeveloped mining sections of the State reasonably accessible. It is expected that the construction of these roads will stimulate many industries which have been discouraged from lack of transportation facilities, besides enabling many mines which have been dormant for want of proper equipment to ship in improved machinery and send out ore or concentrates.

The commission is authorized to employ engineers for locating proposed roads, designing, superintending and inspecting the necessa- tures and receiving the completed w- law provides that the commission shall the width, allowable grades, points for corduroy, drains and turnouts, the dis- the roadway to which trees must be cu- for bridges and their dimensions, and ri- rials for construction. Of course, th- minations can be made only in a gener- the commission, and the technical deta- reach them through reports and recomm- of their engineers.

The law also requires that all work sh- by contract and only after 30 days' ad- for bids. Members of the commission a- hibited from having personal interest in a- contract for work or materials in connecti- with the State roads. Payments to contractors are based upon estimates of work performed and certification by the engineer of fulfillment of contract. On contracts for over $2,000 partial payments may be made on monthly estimates by the engineer in charge, 33% of the amount of each estimate being withheld pending acceptance of work.

The present commission consists of Governor Frank R. Gooding, State Senator M. E- ewis and Mr. Joseph W. Wheeler, all gentlem- of large affairs and progressive ideas. A po- of careful investigation and economy was a- ted at the outset, and the precedent of requir- the communities asking for new roads to e- pend

Fig. 3. Firebox.

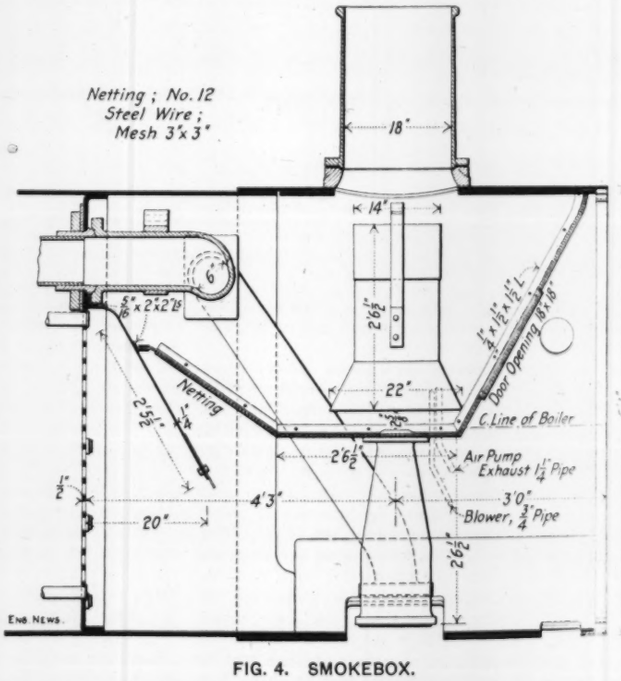

Netting ; No. 12 Steel Wire ; Mesh 3" x 3"
Netting
Door Opening 16" x 18"
C. Line of Boiler
Air Pump Exhaust 1½" Pipe
Blower, ¾" Pipe
ENG. NEWS.

FIG. 4. SMOKEBOX.

*Engineer Idaho Intermountain Wagon Road Commission, Boise, Idaho.

dollar for dollar with the State was established. This plan has closely adhered to and has worked well. The result has been the placing in the hands of the commission of just double the amount appropriated by the State, i. e., roads costing $100,000 construction are thus guaranteed by the Legislature's appropriation of $50,000. The wisdom of this policy has also been apparent in limiting the propositions requiring examination to those for which there is a pronounced and legitimate demand.

So active has the commission been during 1905 that already $43,000 of the State fund and a corresponding sum furnished by the community interests has been applied to construction work or reserved upon contracts, and it is expected that the remaining $14,000 now available will be called for early in the coming year.

Considering the high cost of labor and materials in the mountainous districts, it will be realized from a resumé of the propositions completed or under way that a good deal has been accomplished with the money at hand.

The longest road contracted for will extend from a point near Warren to Big Creek, tapping the Thunder Mountain country. The length of the route is about 35 miles. Whiteway & Hicks, of Boise, have the contract for this road, which will cost $22,000. A wooden bridge across Salmon River, on this road, was let for $3,200 additional. The engineer in charge is Mr. Charles Luck, of Weiser. The work will probably be completed early in 1906.

Another important road, which is well under way, follows the Boise River from Twin Springs to Atlanta, a distance of 44 miles. Storey & Ryan, of Boise, have the contract for 27 miles of this road, which includes two wooden truss bridges across Boise River. The contract price is $20,400. Private interests have undertaken to construct the remainder. The writer is engineer-in-charge. This road will furnish a winter outlet to the mines at Atlanta, where great bodies of low-grade ore await treatment by modern machinery. At present the camp is accessible only about five months in the year.

A road about ten miles long is being built into the Sheep Mountain country at a cost of $7,000, and $5,000 is being expended on a mountain road in Lemhi county. The construction of a four-mile road, to cost $1,793, crossing the summit of the Bear River Mountains, in the southeastern part of the State, has been undertaken by Kuns & Wilcox, of Paris.

Hord & Son, of Wallace, have taken the contract to build a road 2⅛ miles long across the St. Joe divide, and a pack trail 10¼ miles long from Cedar Creek to the St. Joe River, in the Coeur d'Alene country. The contract price was $4,350. Another road in the same region, from Wallace north to Prichard Creek, 14 miles, will require $8,000. A road seven miles in length along the north bank of the Payette River and a 50-ft. trestle bridge across Squaw Creek has been completed at a cost of $3,700. E. E. Stanley was the contractor and Elmer Forshay was engineer-in-charge.

Other propositions are under consideration, and further examinations will be made when the snow goes off in the spring.

From the prices per mile above quoted it will be seen that nothing elaborate in the way of roadmaking can be accomplished. In fact, only a shelf in the sidehills and rocky canyons, sufficiently wide to support traffic, is possible. No surfacing, other than trimming up the natural materials in place, can be done, and only the simplest means of drainage and weather protection can be considered.

The policy of the commission is to open the way for development as quickly and cheaply as possible by routes that can be traveled over with reasonable ease and security, depending upon the stimulation to the mining and other industries to warrant future improvement.

It is then the problem of the engineer to so design and locate the road as to immediately make travel and freight transportation reasonably easy and safe, with an eye at the same time on the possibilities for future improvement. Freighting in the mountains is most often done by six-horse teams and trail wagons, and it is customary to haul from 5,000 to 7,000 lbs. on the two wagons. By dropping the trail wagon at the foot of a hill, proceeding to the top with one and returning after the other, it is possible to surmount pretty heavy grades. Descent is often made with the assistance of rough locks, which, however, cause serious damage to the roadbed, and dependence upon such means is, of course, dangerous.

It may therefore be stated that the limiting grade must be one which heavy wagons can descend with tolerable safety. It has been found that a 12% grade is about the maximum for any considerable distance, though this can be exceeded slightly on short pitches without much danger. It is rarely necessary, however, to stake a grade so steep as 12%, and only when very expensive grading can be avoided is it excusable to exceed that slope for even a short distance.

The Idaho specifications for single track roads call for a roadbed at least 8 ft. wide, this width to be increased to 10 ft. on curves of 75 to 100 ft. radius and to 12 ft. on curves of less than 75 ft. radius. No curve of less than 25 ft. radius is allowable. Turnouts 50 ft. long and 12 ft. wide must be provided within sight of each other, if practicable, or at least on an average of every half mile.

To facilitate drainage, the writer prefers to have the road on cross-section slope slightly toward the inner bank, and crossways or culverts at intervals should carry the drainage away from the road.

It is further specified that all running streams shall be bridged, all dry drainage channels provided with culverts and swampy places corduroyed. Bridges, culverts, corduroy and cribbing shall have a secure supported width of at least 12 ft. Wherever springs are crossed, drainage ditches shall be cut along the upper side of the road and discharged by culverts under the road. (Where lumber was difficult to obtain, the writer has made very satisfactory culverts with flat stones.) The approaches to all bridges and sharp curves shall be level for at least 20 ft., so that the wheel horses can handle the load while the leaders are turning. Cribbing shall be of sound, straight logs not less than 8 ins. in diameter at the small ends, and shall be laid so as to break joints. Dry rock walls must have a batter of at least 1 to 4.

It is usual to specify that all trees, stumps, brush and projecting rocks shall be removed from the roadbed, and that all trees, underbrush and overhanging limbs within 10 ft. of the center of the roadbed, and all dead and leaning trees liable to fall on the road, shall be cut and removed. In rock cuts there should be a covering of earth, sand or gravel sufficient to make a smooth roadway.

Future improvements will be largely in the form of widening and surfacing the roadbed, and a few grades may be cut down, though the latter feature undoubtedly has been the one most carefully studied in locating the Idaho roads.

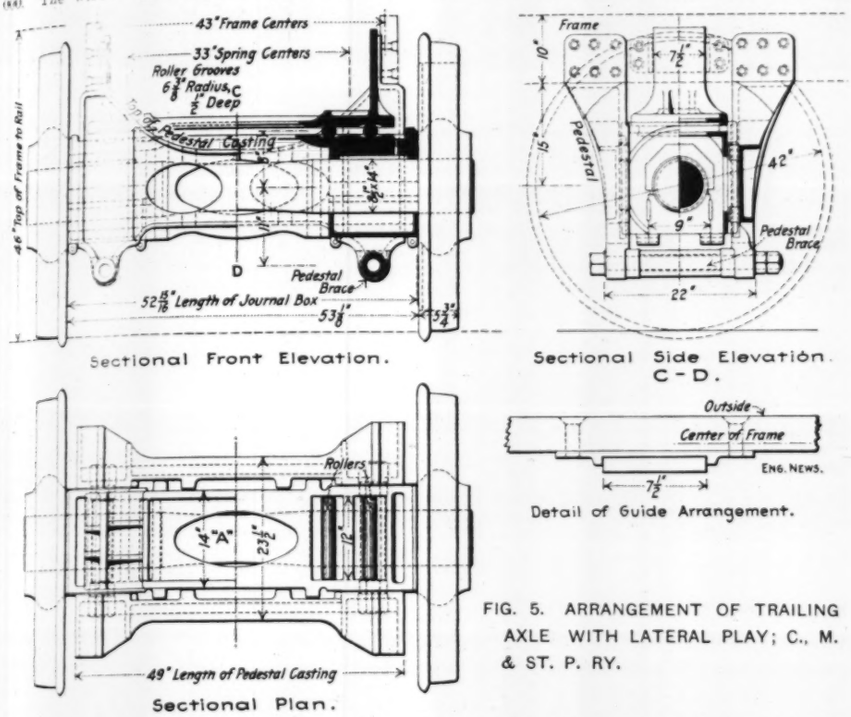


FIG. 5. ARRANGEMENT OF TRAILING AXLE WITH LATERAL PLAY; C., M. & ST. P. RY.

THE DESIGN OF YARDS FOR CLASSIFYING FREIGHT CARS.

By W. A. MacCart.*

On practically all railways the greater portion of the equipment and the larger number of the employees are engaged in the various duties involved in the transportation of freight. The larger part of the revenue is usually also derived from freight. Any improvement that can be made in the conduct of the freight business should therefore be to the benefit of the revenue.

The great desideratum in freight transportation is that after freight is ready for shipment it should be kept moving toward its destination with as few delays or stoppages as possible. But whenever, for the purpose of reclassifying or other reasons, a cessation in the movement is made and a yard of more or less capacity becomes a necessity, it is desirable (in order to avoid the maintenance of separate organizations, decrease the damage to cars and lading, minimize the delays incident to stoppage in yards and reduce the cost of operation) to have one large yard, rather than several small ones at scattered locations. There would also be less cost involved in the construction of one large yard.

It has been shown from records that while a car in transit moves with an average speed of ten miles per hour, when the time detained in yards is added this speed is reduced to four miles per hour; and one trunk line is devoting considerable energy to have its freight trains show an average movement of seven miles per hour.

It is the purpose of this article to invite attention to some of the plans and methods of yard operation now in use and the efforts that are being made to develop some method to minimize this delay to freight traffic.

Until comparatively recent years yards were not designed with any particular method of operation in view, but were simply a series of parallel tracks of more or less length, on which to place cars in order to clear the main tracks and incidentally provide for such necessities as inspection.

*Asst. to Prin. Asst. Engineer P. R. R., Williamsport, Pa.

changing motive power, crews, etc. The process of classification was not considered to the extent that is given to it to-day. That the subject is a live one is evidenced by the plans that have been prepared for many different localities and illustrated from time to time in the different engineering and railroad journals, showing the thought that is being given to the effort to improve this portion of the traffic problem.

The yard of to-day should be considered in the light of a machine, and one which, like all mechanical devices, is intended to expedite or increase the measure of work done. Having this idea in mind, we will be alert to adopt such methods and features as will be shown to give good results and discard such others as do not; but it is difficult at times to eradicate the idea that a yard is a place for car storage purposes.

The location of a yard in reference to its being the best for the future development of traffic and the acquirement in the beginning of sufficient property to admit of further expansion when needed are also matters that have not been given the consideration they merited, due probably to the necessity for economy, and, in some measure, to the fact that present requirements far exceed the most sanguine ideas of capacity, and to changes which could not well be foreseen in the manner of performing the work.

As to the error of acquiring in the beginning too little property, it is well to remember that land in the vicinity of a railroad operation of any magnitude rarely depreciates, except for dwelling purposes. It is only necessary to observe the surroundings of almost any railroad yard or terminal to note how they are so closely encroached upon by industries, etc., that the acquirement later of additional ground is usually only possible at a greatly increased cost.

The writer is aware of an instance occurring within a year where, in acquiring property for a new yard, in order to encroach as little as possible on some land which, in addition to being high-priced, was also encumbered by local restrictions, it was by those interested deemed best to put an angle in a piece of track instead of making it a continuous tangent. Before the grading was half completed it developed that some additions to the plan which were desired could have been made with a much less cramped layout than had to be adopted if ample ground had been purchased at the beginning and the track referred to had been made straight.

The number of tracks and size of yards have been increased from time to time only after urgent appeals by the yardmaster that there was no place to put trains could no longer be resisted. These additions were made, however, without any definite plan, and the result is that yards have grown into a great collection of tracks without order or system, and in many instances covering more territory and containing a greater aggregate length of tracks than would be required if they were properly disposed.

There are many yards in operation to-day where considerable increase in their capacity for doing the work and an economy in its cost would be obtained if a thorough study of the requirements and situation were made and a revision of the plan made accordingly.

This can best be done by a conference of the operating department with an engineer who is familiar with what can be done with tracks and connections, and who at the same time has some knowledge of or can readily grasp the transportation problems, and can plan to meet them. By this method may be remedied many of the defects that have been caused by a lack of co-operation between the operating and construction departments.

The rapid increase in freight traffic during the past few years, with its periods of congestion amounting at times almost to a suspension of business, has forced our traffic officers to diligent study in an effort to solve this transportation problem of how to move freight in the shortest time in such condition as to require little or no handling at its destination and at a minimum of cost. The solution of this problem involves primarily the classification of freight; and, corresponding to the growth of transportation and the need for transportation economy, the amount and complexity of the required classification work has grown and developed. The development of classification, and the variety of the conditions which it has been called upon to meet, have resulted in the evolution and trial of the many types of existing classification yards.

Although several large yards have recently been built wholly to one side of the main tracks, I believe it to be the general opinion that the better location for a yard with reference to the main tracks is between them, as affording the greatest simplicity in connections and details where trains leave and enter main tracks. With the main tracks on the extreme outside also, they are least likely to be affected by any wreck or other trouble which may occur in the yard, and are not likely to be occupied by any yard work. The main tracks should be far enough apart to permit of future expansion of the yard.

In determining what amount expended in changes and improvements in a yard layout would be justified, the items to be considered are (1) to what extent would the movement of traffic be

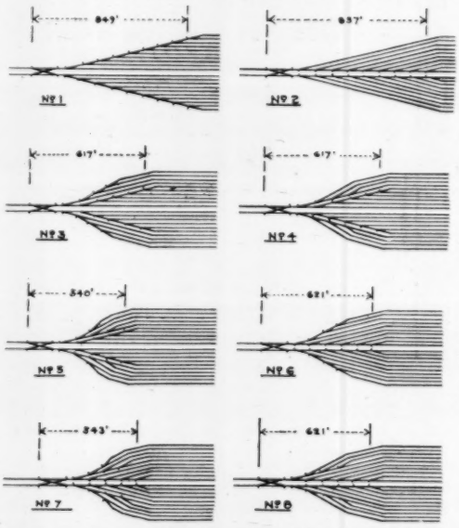


Fig. 1. Sketch Showing Different Arrangements of Switches Leading to Classification Tracks, Showing Comparative Distances to Last Switch in Each Diagram From a Corresponding Initial Point.

increased in either volume or promptness, and (2) what saving in cost of operation would result? For instance, during January, 1904, on one of the Eastern railroads, the repairs, fuel, stores, other supplies, engineers' and firemen's wages and roundhousemen's wages, amounted to 32.6 cts. per mile; the allowance for a locomotive in switching service being 6 miles per hour, or 144 miles per day, or a total of $46.94. Allowing 313 working days per annum, this would amount to $14,692.22 for the year, or the interest at 5% on $293,845, which is the expenditure that would be warranted in making any changes that would dispense with the use of one shifting engine.

As previously mentioned, the proper location of the yard in reference to the work to be done and its future increase, with the idea of concentrating the classification at one point so far as possible, has not in the past been given consideration; and another phase of the situation we are confronted with is, Would it not be better to abandon some of the yards we now have and build one on a new site and rearrange the freight runs to it?

An example of this concentration of operation is to be found at Chicago in the yard of the Chicago Terminal Transfer R. R. Co.,* wherein, under one organization and at one place, it is proposed to conduct the classifying and interchange of freight between all the railroads that now requires each of them to maintain a separate organization.

The classification of freight has been performed by practically three methods of shifting or variations of them, viz.: "push and pull," "gravity." Which is the best for [illegible] location (based on economy of [illegible] only be determined from a full stu[illegible] edge of the situation, including [illegible] work to be done and the probab[illegible] crease, the facilities available, and [illegible] and cost of improving or increasing [illegible]

Mr. C. L. Bardo, in his article [illegible] December, 1903, to the New York [illegible] on "The Design and Operation of [illegible] Tidewater Terminals," gave the rat[illegible] of the various methods of shifting [illegible] mentioned above as 25%, 40% and [illegible] wage expense as 240%, 250% and [illegible] being the base), showing a large ma[illegible] of the gravity method; but, as all t[illegible] are not stated, it is possible these [illegible] might be susceptible of variation if th[illegible] were changed or improved.

A cardinal feature in yard constru[illegible] be that no backward movement is [illegible] that can possibly be avoided, but all movement should be in the direction of the traffic. The first method of shifting named, viz.: "push and pull," is in violation of this principle. The second method, "poling," also violates this principle, but to a lesser degree, as only the engine necessarily makes the reverse movement. The third method, by "gravity," is in accord with the principle.

A purely gravity method of classifying is the one in use at Edge Hill, near Liverpool, England, where the cars are delivered into a receiving yard at the head of a grade, the brakes set on them and the road engine released, after which the successive operations of classifying and making up into trains are done by allowing the cars to drift down grade and dispensing with motive power altogether, an engine not being attached again until the train is made up in the departure yard. This yard, the construction of which was begun in 1873, and which was illustrated and described in Engineering News of May 31, 1894, has a siding capacity for 6,800 cars, the cars being 15½ ft. long, with a capacity of 7 tons.

The average number of cars passing through this yard in 24 hours is stated to be 2,200, of which 320 were empties; while 2,928 cars, or 122 per hour, is given as the maximum number passed, and it is said no increase in the facilities has been found necessary since 1882. The average of 122 cars per hour given above is simply dividing the number of cars moved by 24 hours, and does not represent the maximum actually moved in one hour, for it is stated the greater portion of this work is done between the hours of 4 p. m. and 1 a. m., a period of but nine hours.

I do not consider that the maximum capacity in cars moved per hour over the "hump" has ever been determined, because of the number of conditions against doing so. I have seen cars put over a hump at the rate of eight per minute, or 480 per hour, until the force of "car droppers" or "riders" was exhausted, when the movement necessarily ceased until their return from the classification tracks. Manifestly, it is fair to presume that, with a sufficiently large force of "car droppers" at hand, approximately this movement could have been kept up indefinitely, except in case of cars being wrecked or stalled on ladders or from a lack of cars.

During one hour's observation at Harrisburg there were passed over the westbound (empty car) hump, with no extra effort or attempt at exhibition, 135 cars in 72 cuts. This was on a rainy March day, and included the delays incident to return of droppers from riding cars moving stalled cars, etc.

The "hump method" (as it has generally been termed) of classifying is generally supposed to have been first applied in 1876, at Speldorf, Germany (see Camp's "Notes on Track"). The Honey Pot yard (near Nanticoke, Pa.) of the Pennsylvania R. R. Co. is believed to be the first place in this country at which this principle was applied. This was built about April, 1891, and has been in successful operation ever since, the traffic being almost entirely anthracite coal.

There can be no standard plan made for yard purposes, for the reason that every location is a problem in itself, due to the physical surround-

*Eng. News, Vol. Jan.-June, 1902, p. 12.

ings and the kind and amount of traffic of which a knowledge must be had; the length of trains arriving and leaving in each direction; the number and extent of classifications required; the probable increase or variation in all of these items mentioned; the amount of property that is or can be made available; whether traffic is all "slow freight" or some portion of it fast freight; to what extent car and engine repairs will be made; whether an engine plant and "L. C. L." transfer house is to be included, and if storage is to be provided for "held for order" cars.

In every design are features, which will be enlarged upon as I proceed, to which the greatest consideration should be given, and, profiting by lessons from the past, make first a plan liberal in its estimate of future requirements, following this with a plan showing the immediate requirements, to be built on the lines of the final plan, so as to necessitate the minimum of changes when extensions are made. This is the method followed by the Pennsylvania R. R. Co., which has probably done more in this line of work than any other railway company. To do this, it is necessary to determine the greatest amount of work that can be done at the governing point (usually the throat between the receiving and classifying yards), and to meet which the balance of the plan must be made.

Here I would call attention to the fact that when classifications are made in both directions it is desirable to have these throats separated laterally in order that an accident on one may not interfere with the operation in the other direction. This is mentioned because of having seen some plans in which the hump tracks have been placed as closely together laterally as possible.

In fixing the standing room or length of tracks in the various portions of the yard, due regard must be given to the possibility of increase in length of trains due to grade revisions or an increase in the tonnage capacity of the motive power, or to a decrease in their length due to the use of larger capacity cars. It is generally advocated that the length of tracks in the receiving yard should be such as to accommodate the maximum train passing over the road. To the writer's mind, this does not necessarily apply to all the tracks in such a yard, as in practice traffic is generally handled in long slow trains and short fast trains, which would permit of a variation.

There is another point that must not be lost sight of in these tracks where the "hump" method of switching is used. In providing a "hump" it sometimes happens that the rate of grade immediately approaching the "hump" may be such an adverse one that the longest train could not be pushed over it by the engine assigned to the work. In such a case a system of crossovers should be provided at the center of the length of the receiving yard to provide access by the pusher engine to a portion of the train at a time.

The number of these tracks will depend on various circumstances, such as, for instance, whether the trains arrive in convoys or their arrival is distributed throughout the entire day; or if the greater portion of the classifying is to be done in daylight, storage for those trains arriving at night would have to be provided for; or it may be necessary to take care of an accumulation of cars because of delay in traffic due to wrecks.

The natural place for inspecting and marking the cars for classifying is on the receiving tracks, and a sufficient number of tracks would need to be provided for the delays incident to this. The yardmaster should be advised in advance of the arrival of trains, so that he can prepare for their prompt inspection and marking for classification. In addition to the inspection, some lines provide for very light repairs being made on the receiving tracks (instead of classifying and moving "bad order" cars to repair tracks), with the idea that the delay in movement is not materially increased.

The number and length of receiving tracks having been determined upon, the next feature to require attention is the classification tracks, and the consideration of these will be based on the presumption that the "hump" method will be used.

When the classifications are so numerous as to require a large number of tracks, the problem is then to arrange or group the switches so that the distance between the hump and the most remote switch is reduced to a minimum. There are various reasons for this, one being that the length between extremes of classifying tracks need not be so great; another being that the heavier grade required through the switches need not be so long and consequently the hump not so high, which is a consideration, particularly if it has to be made by an artificial fill; and, again, the switches being closer together, can, if moved from a tower by any mechanical means, be better observed by the leverman or operator, and therefore more quickly moved, or, if thrown by hand, can be operated by fewer switchmen.

A number of plans have been prepared for this purpose, as illustrated in Fig. 1, and there are objections to be found with all of them; but a study of them will show the respective merits and defects, and we can select the one which, in our opinion, will best suit our ideas or serve the purpose. In Fig. 1 the same number of tracks is used in each instance to show the comparative distance from the hump to the last switch.

An objection to all of the plans, excepting No. 1, is that all of the tracks are not straight from end to end, thus making more difficult the passing of signals when making up trains or moving cars from the yard. In case of tracks being added, the ladder shown in No. 1 also lends itself more readily to extension without tearing out the existing switches, but has the disadvantage that each added switch is further from the tower.

The particular advantages in plan No. 2 are that the switches adjoin and that the central ladder tracks are the high ones, thus throwing the drainage to the outside of the yard.

The merits of plan No. 5 are the minimum distance from hump to farthest switch and the grouping of the switches, combined with the maximum number of tracks which are straight throughout their length.

As to the respective merits of classification tracks all of a full train length, or of short classification tracks with a requisite number of advance or starting tracks upon which a full length train can be made up, there will probably continue to be a disagreement, due possibly to somewhat different methods followed by yardmasters in handling the movement.

The writer considers the method of using advance tracks and short classification tracks the better, for several reasons, viz.:

(1) It is not likely any classification will be held for the accumulation of a train length.

(2) The road crew should not be used to make up a train from the different classification tracks, because it will be liable to involve the questions of overtime and performing a different class of work from that for which they are employed.

(3) The element of danger from making up trains on the classification tracks when cars are being sent into them from the opposite end.

(4) Fewer car droppers are required, because of their quicker return to the hump, due to short tracks, and a consequent less delay in the operation.

(5) The yard crews should be used in making up trains on advance tracks at such times as cars are not on hand for classifying.

(6) The road crew need not be called until the making up of a train is assured, thus saving overtime.

(7) Less financial outlay and future maintenance, as there will generally be less graduation and track required, as the tracks require a grade for almost their entire length to insure against cars stalling.

(8) A lower elevation of hump would be required to insure cars moving the entire length of tracks, and consequently less cost for construction.

GRADES.—The question as to the rates and lengths of grades to be used from the hump into and through the classification tracks is one upon which there is considerable difference of opinion.

The following are some of the factors which have to be considered, and frequently an average for them must be adopted:

Character of traffic.
Influence of the weather.
Direction of the prevailing winds.

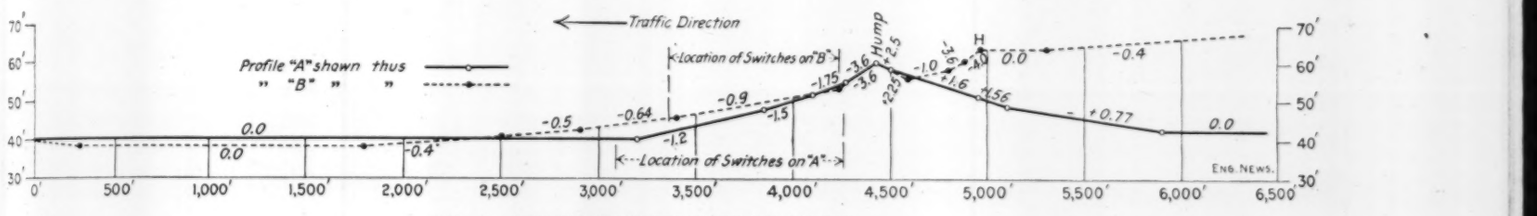


FIG. 2. COMPARATIVE PROFILES OF HUMPS.
(Grades Given in Per Cent.)

"H" shows original location of hump, and because of being too far from switches, a new one was constructed at location marked "Hump" and the —0.4% grade later extended to that point.

Condition of the tracks.
Kind and condition of cars.
Number of cars usually in a "cut" or draft.
Weighing of cars.

Considering these in order, it should be known if the movement is to be entirely empty cars or loaded, or composed of both, and also if lading is uniform in character (as coal or ore) or miscellaneous, as a grade that will permit the handling of loaded cars will not suffice for a prompt movement of empty cars, and, of course, the establishment of a grade that will accommodate both loaded and empty cars is much more difficult.

THE INFLUENCE OF THE SEASONS.—The difference between summer and winter is a very large factor in the ease with which cars will run, particularly the extremes of temperature sometimes reached in the winter, chilling the lubricants and causing everything to run hard, especially if the train is not handled soon after its arrival and is permitted to "freeze up," as it is sometimes termed. Experiments show the internal resistance of freight trains to be 1½ to 2 times greater in winter than in summer, due largely to the difference in journal friction at low and high temperatures.

The prevailing direction of the wind should be considered, as it also has an effect, especially on empty box cars. The condition of the tracks as to line and surface (particularly through the ladder tracks, where the resistance of switches, frogs and guard rails is encountered) should be watched, as tracks in good order will require a less rate of grade than rough tracks. The class and condition of the cars themselves is such that a specific grade would not serve for them all; cars that have just come from the repair tracks, for instance, are usually "hard running." The average number of cars in the "cuts" or "drafts" must be considered, for while those of one or two cars each may leave the hump very rapidly, those

of five, eight, ten or more cars will be very much retarded because of the front cars being held back by those in the rear, unless a very long and heavy initial grade is used.

The weighing of the cars in connection with their classification requires the introduction of a rate of grade over the scales that will give a speed not prohibitive to weighing. In this connection it would be well to note that unless the "to be weighed" cars are in the majority the straight track should be the "dead rail" one and the scales be located on the turnout.

To illustrate the difference in opinion as to rate of grade required, there is given in Fig. 2 a comparative illustration of two humps on the same railroad system, in which the traffic passing over them was the same, viz.: empty cars, principally gondolas of all classes and capacities.

Observations were made at each of the humps, with the following results: For the total time consumed the number of cars passing over "A" was 1.4 times that at "B," and when a short-time observation was made, which did not include any delays or stoppage in the movement whatever, the rate obtained at "A" was as much as 2.4 times that at "B." It will be noticed that the rate of grade of profile "A" is greater than at "B," and it must also be known that when these data were taken the weather at "A" was rainy, with a temperature of 40° above, and wind favorable to the movement, while at "B" it was clear, with a temperature of 21° above, and a strong adverse wind. It is not at all the intention to give the above results as final, for the reason that the observations were not of sufficient length, but merely to show that the various factors exercised an influence on the results obtained.

The manner of operating the switches into the classification tracks varies. At some places it is done by electro-pneumatic machine located in the second floor of a tower near the hump, from which point the operator or his assistant can see both the marking on the cars indicating the track to which they are destined and also the position of the switches. The latter, or the moment when the car has passed the frog point, is sometimes electrically indicated at the operator's table.

At other places the switches are manually operated, those nearest the hump, to the number of ten or twelve, being pipe connected and operated by levers (as in an interlocking machine, but with the interlocking omitted) in the second story of a tower; the more distant switches on the ladders being pipe connected and the levers grouped and operated by a switchman on the ground. Both involve a method for indicating to the various switchmen the destination of the car, or "cut," as it is usually termed.

A common method is to mark the cars to show where they go, the first "cut" usually bearing at its front end its own destination and at the rear end that of the next following cut. All succeeding cuts are then marked to show the destination of the following cut. This system of marking, however, is only applicable for daylight, and different schemes are resorted to for night switching, a code of signals generally being devised and understood by the trainmen themselves, who become very expert in this matter. These methods, of course, vary with different localities.

When a train is started for classifying, the operator or leverman is usually furnished with a slip showing the number of "cuts," the number of cars in each cut and track to which destined. The operator also is provided with some means of controlling the engine pushing the train over the hump, so that it may be stopped or started, as emergencies arise. At some places this is done by a large air whistle at the tower from which the switches are operated. At times of storm or where fogs prevail a series of semaphores could be spaced at intervals along the receiving tracks in such a manner as to be readily seen from the engine pushing the train.

ADVANCE TRACKS.—As previously stated, the use of advance or starting tracks, while allowing shorter classification tracks to be used, will increase the extreme length of the yard; but it is questionable if the money saved by their use in permitting trains to be air tested and made ready before crews are called will not warrant their cost.

TRACK SCALES.—While the track scales have been mentioned previously in connection with the grades on the hump, their location is a feature upon which there is disagreement. If located on the hump, in order that the speed over the scales shall not be too great, a rate of grade is introduced that has a retarding effect as well on all the cars not weighed. Some plans have been prepared in which the scale is not placed on the hump grade, but the cars are classified to a "scale track," and after weighing returned to the receiving yard to be classified as to destination, etc. It is a question as to which method causes the most detention, and its answer would probably depend upon the percentage of cars to be weighed.

The location of cabin or caboose tracks should be such that when the cabins are cut from the incoming trains they would reach the storage tracks ready to be dropped in their proper order behind a leaving train.

If an L. C. L. transfer shed and a re-icing plant are required, the problem is still further added to, for they must be made readily accessible from the classifying and other tracks in both directions.

For the general lighting of the yard a layout could be made and the proper spacing left between tracks for the poles so that they will not be a menace to life. Where electricity is available a trolley car (instead of a locomotive and car) for returning the car riders from the classification tracks to the hump would probably be more economical.

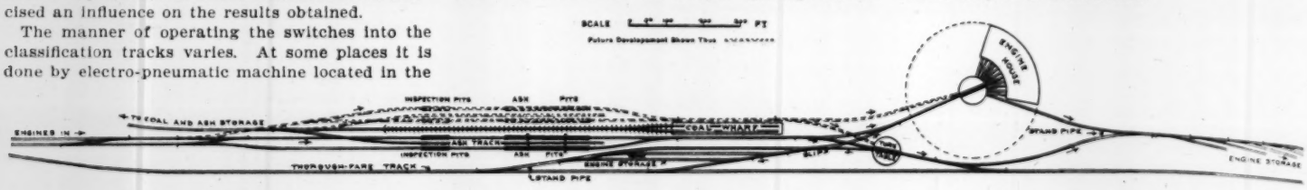


FIG. 3. PLAN OF ENGINE FACILITIES AT TERMINALS.

TURNING OF ENGINES AND SHOP FACILITIES, INCLUDING CAR REPAIRS.

The facilities for the inspecting, cleaning and coaling of engines and for the repairs of "crippled cars" will need careful study. A poor location of the facilities or a bad arrangement of tracks, with crossing and conflicting movements, making it difficult for an arriving engine to reach the inspection and ash pits and coaling wharf, also "turning," as it is commonly called, is frequently a cause of delay in prompt movement of trains.

Not only the access to these facilities from the receiving tracks, but their location with respect to each other should be well considered, so that the movements may be as quick and direct as possible to inspection and ash pits, coaling wharf, turntable, etc., and thence to the departure tracks or the engine storage yard, ready for a call for power. In this connection a turntable independent of the one at the roundhouse is a valuable addition.

Recent practice seems to be on the lines of providing an engine-house or roundhouse only for engines needing repairs, the necessity for these repairs being determined at the inspection pit, and, if needed, advice of their nature is at once furnished to the roundhouse, so that by the time the engine has been cleaned and coaled preparations for its location in the roundhouse have been made.

The amount of repairs that will be made to the power must also be considered, and space allotted for the necessary shop buildings, not only for the existing traffic, but for a prospective increase, and storage room for supply coal and ashes must not be forgotten.

Fig. 3 shows the layout of this portion of a recently designed yard.

Providing for car repairs also con[illegible] as elsewhere stated, very light repa[illegible] times be arranged for on the re[illegible] but for heavier repairs they are cla[illegible] are termed "cripple" or "hospital" [illegible] paired there or further moved into [illegible] pair yard. It sometimes occurs [illegible] centage of cars requiring repairs is [illegible] direction than in the other, and in [illegible] the repair tracks should be locate[illegible] accessible to the larger percentage, [illegible] cars can, with a minimum amount [illegible] pass from the cripple classification [illegible] repair yard, and after the repairs [illegible] be returned to the receiving track [illegible] proper classification.

It must be determined whether [illegible] necessary for these repairs shall be [illegible] already prepared from some other [illegible] largely or entirely prepared in sh[illegible] erected. Shops must be adapted to exp[illegible] departments, so that, when the yard [illegible] is developed to its maximum capacity, [illegible] tures may not be cramped and involve [illegible] changes to secure sufficient room.

Plans have been prepared with separate engine facilities and car repair tracks at each end of the yard to care for the traffic in opposite directions. While this undoubtedly made these features more accessible, unless the amount of traffic was very large, the duplication of buildings and the increase and separation of forces needed to operate them would not be warranted; and, as this is one of the fixed charges per car, which is greater or less, in proportion to the traffic, the aim should be to keep it at a minimum.

Yardmaster's offices, bunk rooms and other buildings necessary to the operation of the yard must be considered and their location fixed so that they will be readily accessible and not interfere with the expansion of the general layout.

Last, but not least, a "thoroughfare," or running track, throughout the entire yard should be provided, so that movements can be readily made at any and all times between all parts of the yard. It is desirable that this track should be run in one direction only, or else be made a double track; if a single track is used, passing points should be provided at suitable locations.

By having a water supply in the vicinity of the hump for the use of the yard engines, the delay necessary for running to the engine facilities can be avoided, except at such times as the engines required cleaning or coaling, and even these features could be provided near the hump if warranted.

If night work is to be done, an electric lighting system is a very necessary adjunct, and the different portions of the layout should be connected by telephone to the yardmaster's office.

It will readily be seen, therefore, that the subject is by no means a small one, because every proposition requires an analysis and treatment of its own, as the conditions are so varied. For this reason there should be a department of Yards and Terminals, in charge of a supervising engineer, where records, made from personal observation of all available operations, can be kept and the results compared.

This would, of course, require observations in winter and summer, noting the effects of the extremes and averages of temperature and weather conditions, and these notes and plans should certainly be made under the supervision of one person, who, from constant dealing with the problems, would remove them from the field of experiment only.

To emphasize this, it is only necessary to refer to the profiles "A" and "B" in Fig. 2, which, as stated, are on the same system, less than 200

miles apart and designed for the same kind of traffic, have been made by different persons, without any consultation. Although "B" was the last prepared, the location of the hump was defective and the changes were insufficient, both of which had to be remedied before the best results could be obtained.

A reference to the various plans and profiles illustrating from time to time shows the differences in opinion of the various designers. In many instances it will be found the grades operated are not strictly in conformity with the plans as originally prepared and illustrated; hence the necessity to make a personal investigation to know what is being done, and as well the method and conditions. In one instance the hump is raised and lowered for winter and summer use, respectively. This is done by filling in and digging out, and does not require much time.

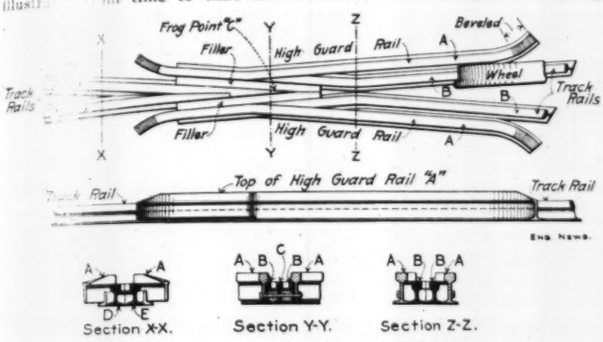


Fig. 1. Frog with Elevated Wheel Guards.
J. E. Conley, Arcola, Ill.; Inventor.

FROGS WITHOUT GUARD RAILS.

Frog guard rails are necessary and important adjuncts at all frogs (although occasionally omitted in yards), and upon their proper position and maintenance depend in large measure the wear of the frog and the safe and easy passage of wheels through the frog. Their function is to hold the outer wheels in line so as to prevent any inner wheel from striking the frog point or taking the wrong side of the point. On curves or bad track and at sharp frogs, the work of maintaining the guard rails in position is often continuous and costly, especially if they are not attached to the running rails (as they should be), but simply held by spikes and rail braces. The guard rail engages the back of the outer wheel, guiding this wheel into line, and thus (through the axle) pulling the inner wheel into line. In case of a loose wheel, badly gaged wheels, sprung axle or truck out of center, this guiding of the outer wheel may not put the inner wheel in proper position to take the frog, and two designs of frogs are now in experimental use, which are intended to guide the inner wheels and so dispense with the ordinary guard rails opposite the frog. To effect this, the frog is fitted with guards which guide the wheels by contact with the face of the rim instead of the back of the flange (as in the case of the guard rail), and to effect this it is necessary to raise the guard slightly above running rail.

FIG. 3. FROG WITH ELEVATED WHEEL GUARDS.
Graham Flange Frog Co., Salem, Va.

The Conley frog, shown in Fig. 1, is the invention of Mr. J. E. Conley, of Arcola, Ill., and has as its special feature the outer raised guard rails, A, bolted to the frog rails B. The heads of rails A and B are mated and fastened so that the head of the latter passes under the former for a short distance, and in this way a support for the tread of the wheel is provided all the way until it comes upon the frog point C, formed by the rails D and E. The usual filler blocks are used between the frog point and wing rails. Wheels and trucks in proper condition will pass over the frog without encountering any extra resistance, but should the wheel be in such position as to be liable to catch the frog point, it will encounter the guide rail or guard and be forced over and guided through the frog regardless of the position of the outer wheel. The illustration shows the frog built up of rails, but the guards can be made of steel bars or steel castings.

A No. 10 rigid Conley frog has been in use on the outside of a 12° curve on a switching lead in the Illinois Central R. R. yards at East St. Louis, Ill. This is shown in Fig. 2. We are informed by Mr. Geo. E. Boyd, Roadmaster, that in his opinion it will give satisfactory service for yard use and slow-speed tracks, but that he would not care to give an opinion as to its utility in a high-speed track until he had seen it tested. For the following particulars we are indebted to Mr. Boyd:

The frog is placed in a crossover at the throat of what is known as our "Island" yard at East St. Louis, and all the switching done in this yard must pass through the frog. It was placed at this point on Dec. 19, 1905, and so far has proved very satisfactory. The service is such that an ordinary frog will usually wear out in from two to three months and on account of curvature we have heretofore been compelled to reset the guard rails two to three times a week; scarcely a day passes without some repairs being necessary. Since the frog was installed absolutely no repairs whatever have been made. The oil which is always found on the outside of the wheel acts as a lubricator on the guard rails outside and reduces the wear on this part, and in the six weeks the frog has been installed, there is no evidence of any wear on the point, showing that the wheel flanges so far have been kept clear of the point.

As far as the operation is concerned, I am free to say that I believe the frog in question is superior to the ordinary frog and guard rail arrangement, inasmuch as there is no question in my mind but that it will safely guide a broken flange or bent axle through the frog without danger of derailment. However, I would not like to express an opinion as to its desirability in high-speed track until tests have been made.

As to comparative cost I can give you no figures, as this frog was made on a special order by the Elliot Frog & Switch Co., and it is reasonable to suppose that it is considerably higher than would be in case of a frog made for commercial quantities. However, in my opinion a frog of this design should be turned out for less than the ordinary frog and guard rail with fillers.

As to the guard rail bolted to the frog being objectionable on account of being higher than the wing rail. The guard rail is beveled at the end in such a manner that anything dragging on a car which would pass over an ordinary frog will pass over this frog without difficulty, and I do not believe that this is an objectionable feature in the slow speed track. It might be, however, on a high-speed track, and this particular point is the only one that I can think of against the frog for use in high-speed track.

The Graham frog, Fig. 3, is of very similar design to the one already described, but has flange blocks or guards of Menard hardened steel bolted to the frog rails. These guards are 1⅛ ins.

Fig. 2. Frog with Elevated Wheel Guards in Yard Track at East St. Louis, Ill.

above the running rails at the highest point, and before the wheel flange leaves the throat of the frog the face of the wheel is squarely against the guard, which is here 1 in. high and holds it in position until the wheel has passed the frog point. These frogs are handled by the Graham Flange Frog Co., of Salem, Va., and one of them has been in service on the Norfolk & Western Ry. for about two months. We are informed by officials of the road, however, that it is on a siding where it is very little used, and also that they are of opinion that the use of such a frog must be restricted to unimportant yard tracks where the movement is slow.

It is to be noted that the applicability of this type of frog to high-speed tracks is considered questionable, and no trials have yet been made under such conditions. Whether the violent blow of a wheel striking its face against the ground would be more dangerous or destructive to wheel and truck than the sudden pulling over of a wheel by a guard rail is a disputed point that can only be settled by actual and extended trial.

EXPERIMENTS ON THE AMOUNT OF HEAT REQUIRED TO PREVENT ICE FORMATION ON THE STEEL LOCK GATES OF THE CHARLES RIVER DAM.

By Walton H. Sears.*

The legislative act authorizing the construction of a dam across the Charles River between the cities of Boston and Cambridge, Mass., by the Charles River Basin Commission, requires that the lock be kept sufficiently clear of ice to permit the passage of vessels. It is proposed, therefore, to heat the lock gates during freezing weather, so that they shall be free of ice at all times.

These gates are to be steel caissons about 48 ft. long and 6 ft. wide, the lower gate being 33⅜ ft. high and the upper 26⅞ ft. high. There is

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one gate at each end of the lock. Each travels on a track at right angles to the center line of the lock, retreating into a recess in the masonry. The down-stream faces will be exposed to the rise and fall of the tide, and must be heated over a range of about 10 ft.; the up-stream faces are exposed to the practically constant level of the basin, and will be heated over a range of about 3 ft. in height.

No reliable data being available by which the amount of heat required to do this work could be computed, it was decided to attempt to determine this experimentally, and also, if possible, to ascertain the most feasible method of supplying this heat. Following is a description of the apparatus used in the experiments and the manner of conducting the tests:

Two steel tanks, 5 ft. high, one of 3 ft. and the other of 4 ft. diameter, bolted together at the bottom, one within and concentric with the other, were partially submerged in water and frozen in. These reproduced the conditions of the lock gates, which are to be steel caissons. The tanks were then warmed until free from the surrounding ice, and heat was supplied fast enough to prevent further freezing around them. The depth of submergence could be varied by means of chain falls, by which the tanks were suspended from an overhead framework. In the 6-in. annular space between the tanks were two double-turn coils of 1-in. pipe, each entering from and returning to the interior of the inner tank (see Fig. 1) and arranged so that steam could be supplied to either or both at once. In addition to these coils, there was at the bottom of the annular space a third coil of ¾-in. pipe, perforated with 1-16-in. holes pitched about 2 ins. Steam could also be supplied to this coil. This arrangement made possible the following three methods of supplying heat:

(1) Using radiator coils of 1-in. pipe, with air in the annular space.

(2) Using same coils, with water in the annular space.

(3) Using perforated coil of ¾-in. pipe, blowing steam into water in the annular space.

The first method would correspond to placing radiators back of the skin plates of the gates; the second to circulating hot water on the inner faces of the skin plates; the third to blowing steam into a sheet of water in contact with the inner faces of the skin plates. The relative structural difficulties of these methods, as applied to the gates, will not be here discussed.

The inside surface of the inner tank being thoroughly coated with asbestos and the top of the annular space being securely sealed with hairfelt and boards, all heat supplied was assumed to have been radiated externally. Any error in this assumption is on the safe side.

A diagram of the arrangement of piping for Methods 1 and 2 is shown by Fig. 2, which figure is self-explanatory. The trap was composed of a piece of 6-in. wrought iron pipe, with a cast iron cap screwed on each end. The water level therein could be seen at all times by means of a water glass, and this level, controlled by valve "a," was maintained as nearly constant as possible and was always brought at the close of a test to the level at which it stood at the start.

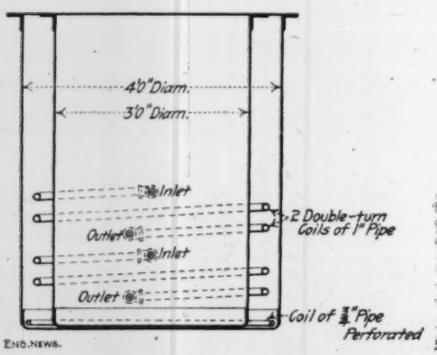


Fig. 1. Section through Tanks.

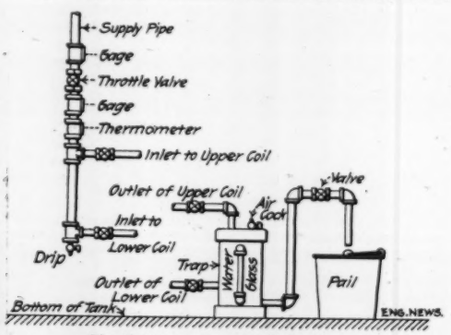


Fig. 2. Diagram of Piping.

FIGS. 1 AND 2. APPARATUS USED TO DETERMINE AMOUNT OF HEAT REQUIRED TO PREVENT ICE FORMATION ON THE STEEL LOCK GATES OF THE CHARLES RIVER DAM.

The condensation discharged by the trap was collected in pails and weighed. The drips were kept open constantly and all piping was covered with non-conducting material. All the valves were within reach of and controlled by the operator, who remained in the inner tank during a test. The tops of the tanks were covered with a large piece of canvas. Thermometers were placed in the trap and in the annular space at 4, 16, 28, 40 and 52 ins. above the bottom, and in some tests, when the pressure was taken on the coil side of the throttle valve, in the supply pipe to show if there were any appreciable superheating due to the throttling. As this last thermometer showed in all cases practically the temperature of saturated steam at that pressure, it proved, by the principle of the throttling calorimeter, that the priming of the steam on the boiler side of the throttle was about 2%. In some of the tests, when the pressure was taken on the boiler side of the throttle and the steam assumed dry at that pressure, the error must have been, therefore, about 1.2%, which, however, was on the safe side and quite negligible, considering the probable accuracy of the whole apparatus.

There were in the tests four distinct conditions of radiation: (1) Air inside to the atmosphere; (2) air inside to water outside; (3) water inside to the atmosphere; (4) water inside to water outside. Of these conditions (2) and (4) were useful in preventing the formation of ice. The B. T. U. radiated per square foot of radiating surface per hour per degree Fahrenheit difference of temperature between inside and outside in each of the above conditions will be designated by Q_1, Q_2, Q_3 and Q_4, respectively. Q_1 and Q_3 were determined by special radiation tests, in which the tanks were hoisted clear of the water. These tests are Nos. 8 and 9, respectively, in the accompanying table. Q_3 was easily determined, since the temperature of the water in the annular space was at any one time the same throughout the mass of the liquid. The annular space was filled with water up to within 7 [illegible] top, and the steam blown in caused [illegible] to flow out at this level through a hole [illegible] provided for the purpose. The heat ra[illegible] then the total heat in the steam sup[illegible] that returned by the water at the ove[illegible] that used in raising the temperature of [illegible] in the space during the test. Allowance [illegible] made for radiation by the 7 ins. of air [illegible] Q_1 was not so easily found, since the te[illegible] of the air in the space varied considera[illegible] bottom to top. For the purpose of fi[illegible] average temperature difference in this [illegible] 9), it was therefore necessary to mak[illegible] showing this variation. From this plot [illegible] age temperature was obtained by the use [illegible] planimeter.

The quantities Q_1 and Q_3 were applied [illegible] exposed portion of the tanks in the re[illegible] tests, and the heat passing usefully into [illegible] outside water, from which Q_2 and Q_4 were ca[illegible] was obtained by subtraction. In expressing Q_2 and Q_4, the temperature of the water outside the tanks was assumed to have been 32° F.

The tests indicated that the placing of radiators in air chambers behind the skin plates is a feasible method of preventing ice formation on the gates, provided it is not necessary to keep the ice away more than a few inches. The behavior of the apparatus also indicated that with any method using hot water in contact with the skin plates it would be a very easy matter to supply heat much faster than necessary. That such a waste of heat would mean a considerable loss will be realized when the large radiating area is considered. The actual design of the piping has not yet been completed, as, in fact, the method of heating to be used has not been definitely decided upon.

The discrepancies in the results of the different tests are explained by the varying atmospheric conditions and mainly by the difference in wind velocity on different days. Furthermore, it was noticed that the more rapidly heat was allowed to enter the apparatus, thereby increasing the space of free water around the tanks, the higher the values of Q_2 and Q_4 obtained, this being probably due to the increased opportunity for circulation of water around the tanks and the increase of free water surface exposed to the atmosphere. More extended tests were contemplated, but were prevented by continuous mild weather.

The results obtained, however, are of much value, it being now possible to predict with reasonable certainty how much heat will be radiated to the air and to the water under various conditions, whatever method of heating is employed.

The Charles River Basin Commission is composed of Dr. Henry S. Pritchett, Chairman, Mr. Henry D. Yerxa and Mr. Joshua B. Holden; Mr. Hiram A. Miller is chief engineer, and the study was made by the writer under his direction.

SUMMARY OF RESULTS OF EXPERIMENTS ON AMOUNT OF HEAT REQUIRED TO PREVENT ICE FORMATION ON THE STEEL LOCK GATES OF THE CHARLES RIVER DAM.

No. of test.	Method.†	Duration in hours.	Steam pressure (absolute) lbs. per sq. in.	Temperature in trap, or of overflow. Deg. F.	Pounds of steam used.	Total B. T. U. supplied.	B. T. U. consumed in raising temperature of water in the annular space.	B. T. U. available per hour.	B. T. U. radiated to atmosphere per hour by air in annular space.	B. T. U. radiated to atmosphere per hour by water in annular space.	B. T. U. radiated usefully to water per hour.	Average difference between temp. in ann'l'r space and temp. of outside water.	B. T. U. radiated per sq. ft. of radiating surface per hr. per degree F. diff of temp. between inside and outside.			
													Q_1 Air inside to Atmosphere.	Q_3 Water inside to Water outside.	Q_2 Water inside to Atmosphere.	Q_4 Water inside to Water outside.
1	2	2½	21.3	201.3	228.1	224,100	8,780	86,130	6,700	0	79,430	108	.....	.....	.....	30.4
2	2	2	21.6	188.6	154.7	154,000	11,860	71,070	9,250	0	61,800	147	.....	.....	.....	30.1
3	1	1½	67.3	203.0	27.0	27,050	.....	18,080	10,990	.....	7,040	59	.....	4.51	.....	.....
4	3	2	19.1	87.2	109.6	120,100	20,600	49,750	3,490	1,880	44,380	51.9	.....	.....	.....	31.7
5	2	3	18.8	162.3	139.6	142,300	31,970	57,500	9,140	4,960	43,400	83.5	.....	.....	.....	35.6
6	3	2	65.7	85.5	87.1	97,650	32,300	32,680	4,410	2,160	26,110	52.5	.....	.....	.....	34.2
7*	1	1½	66.9	Not observed	20.5	between 20,400 & 22,250	.....	between 13,600 & 14,800	12,100	.....	between 1,530 & 4,000	45.5	.....	bet. 2.22 & 4.02	.....	.....
8	1	1½	69.5	191.7	18.21	18,460	.....	12,306	.....	.....	.....	.....	3.22	.....	.....	.....
9	3	3	66.8	119.0	87.0	94,500	50,500	14,670	1,000	13,760	.....	.....	.....	.....	3.11	.....
10	2	1½	20.5	59.0	21.8	24,530	.....	16,350	2,510	1,240	12,600	21.2	.....	.....	.....	26.6
11	1	2	20.1	111.0	18.9	20,300	.....	10,150	8,290	.....	1,860	61.9	.....	1.84	.....	.....
12§	2	1	....	.....	0	0	−16,360	16,360	4,950	2,180	9,280	26.3	.....	.....	.....	15.4
13	2	2½	19.7	61.0	63.5	71,200	15,820	23,730	4,730	2,440	16,560	37.4	.....	.....	.....	19.5

* Trap temperature assumed between limits.

† Method 1: 1-in. radiator coils with air in the annular space. Method 2: Same (1-in.) coils, with water in annular space. Method 3: Perforated ¾-in. coil, through which steam is blown into water in annular space.

§ No heat supplied; tanks allowed to cool.

PAPER VI

RUBBER INSULATION FOR ELECTRIC CABLES.

By [illegible]amlyn, Assoc. Am. Inst. E. E.

The [illegible] of paper or rubber insulation for electric[illegible] cables has brought forth much bitter[illegible]t among engineers ever since the introd[illegible]f paper as a substitute for rubber, previo[illegible] universal use for cable insulation. Of th[illegible]ers who have taken part in this argum[illegible]me represent manufacturing companies[illegible]s represent different electrical systems[illegible]arge quantities of cable; all have, however[illegible]losely guarded the real facts in the case [illegible]prejudiced engineers have had little opportu[illegible] to get at the truth. A discussion of the q[illegible]n may therefore be of interest here. Since [illegible]rent classes of service and different voltage[illegible]equire altogether different qualities in an ins[illegible]ng material, it is desirable to confine a discu[illegible]n of this kind to a particular class of requirements. The subject will therefore be considered with reference to cables for three-phase distribution to sub-stations in cities. Cables for this service run in tile conduits underground, are of the three-conductor type, and are usually operated at a frequency of 25 cycles and at potentials from 6,000 to 12,000 volts.

An idea of the difficulty of insulating the conductors in such cables may be obtained by reference to the accompanying drawing, which shows a cross-section of one of the standard sizes of cable used in New York City carrying 6,600 volts. The conductors are each composed of 37 strands of copper, equivalent in conductivity to No. 0000 A. W. G. solid wire. The insulation around each conductor is 5/16-in. thick, while that between the three conductors and the lead sheath is 1/8-in. thick. The whole cable is but 2⅞ ins. in diameter. Between each pair of conductors there is thus a wall of insulating material 3/8-in. thick to withstand an effective voltage of 6,600, while between any conductor and the lead sheath there is 5/16-in. of insulation.

For insulating such cables, both paper and rubber are in successful use in many places, and have been for a number of years; so that the simple test of time cannot be called in to settle the question of preference. A manufacturer of rubber cables will assure you that no self-respecting engineer will install paper cables, on account of their unreliability. In answer, a manufacturer of paper cables will point to the electrical system where his product is used and where reliability of service is of the utmost importance.

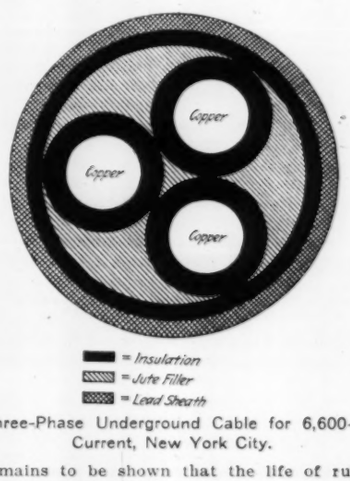
COST.—There is one point about which there is no disagreement, i. e., the first cost of paper cables is less than the first cost of rubber cables, these costs being approximately in the ratio of $1.25 to $2.00. We are immediately led to inquire about the costs of maintenance and depreciation of the two types. If this running charge for paper cables is so high as to make the sum of interest on first cost and annual charge for maintenance and depreciation greater than for rubber cables, then paper cables are not cheaper than the rubber insulated.

These costs, if they have been determined (and it seems very likely that they have been), are not published, and it is practically impossible to get any data concerning them. Of course, the manufacturers of either kind of cable, or people working in their interests, have figures showing that one kind of cable is cheaper to keep in repair and will last longer than the other, but such figures cannot be accepted as being based on conditions that are fair to both kinds of insulation.

LIFE.—Both paper and rubber cables are usually encased in a sheath made of lead with a small percentage (2 or 3%) of tin, or of lead with a thin coating of tin outside. Lead is used because it can readily be formed into a pipe about the core of the cable without injuring it, and it does not oxidize to any extent. The addition of the tin tends to harden the sheath. The object of the sheath is to protect the core from mechanical injury, to keep moisture from paper insulation and to keep gases, street drippings and oily substances from rubber insulation.

Lead, in spite of its other advantages, is nevertheless, subject, like all other metals, to the electrolysis due to the return currents from grounded electric systems. The effect of electrolysis is to cause holes in the lead sheath, through which sooner or later moisture, gases, etc., will find their way. Blow holes and other defects in the manufacture of the sheath, as well as holes due to mechanical injury, will, of course, bring about the same result. If moisture gets into paper insulation, the paper absorbs the water and becomes practically a conductor, thereby disabling the cable. But it is stated on good authority that the deterioration of the paper under such circumstances is a slow process, occupying days, or even weeks; so that trouble can usually be detected by the regular insulation tests before a burn-out, with its possible interruption of service, actually takes place. Pure water will have little or no bad effect on rubber, but the water in conduits and manholes of underground systems in cities holds in solution various acids and other substances, and, in addition, oils and gases are always present in greater or less quantity. These acids, oils and gases all tend to deteriorate rubber. Now, this deterioration of rubber, when it does occur, seems to take place so rapidly as to cause a burn-out before any trouble can be detected.

While, therefore, it may be said that the life of paper cables is limited to that of the sheath,



A Three-Phase Underground Cable for 6,600-Volt Current, New York City.

it remains to be shown that the life of rubber cables, installed where ordinary city conditions obtain, is independent of the life of the sheath. This is especially true in view of the well-known action of even dry air on rubber.

Vulcanized rubber is more flexible, can stand a higher temperature, and is mechanically stronger than pure rubber; consequently rubber is used in the vulcanized form. Any excess of the sulphur used in the vulcanizing process over the amount which combines with the rubber will act on the copper conductors, forming a sulphide of copper, which in turn reacts on the rubber. With the gases and moisture present (and it is almost impossible to avoid them), the rubber soon becomes decomposed, sticky and viscous and the copper is gradually eaten through. To prevent this action, either the conductors must be tinned or a thin layer of pure rubber must be placed on them before the vulcanized rubber is applied. Either will increase somewhat the cost of the cable, and the application of a coating of tin will, in addition, lower slightly the conductivity of the copper.

Vulcanized rubber, while it will last longer than pure rubber, is by no means free from deterioration. Moreover vulcanized rubber, in order to afford good and reliable insulation against high-tension currents, must be made of a good quality of rubber, and it must be vulcanized with great care. Now it is practically impossible for the purchaser to determine by any tests, before the acceptance and installation of cables, that a good quality of rubber has been used in any given case, or that the vulcanization has been properly done.

When paper was first used it did not give good satisfaction, because it frequently cracked. This difficulty has been overcome by improved methods of treating and applying it, so that paper insulation as now made will last almost indefinitely, provided it is kept dry.

MECHANICAL AND ELECTRICAL PROPERTIES.—Paper will stand a temperature of 90° C. for a time without any bad effect, although the regular working temperature should not be allowed to rise as high as this. Rubber cannot stand more than 65° or 70° C. for even a short time without softening. The kinds of paper used in cable insulation are practically incompressible, and will therefore maintain the proper distance between the conductors, and between the conductors and the sheath; rubber, on the other hand, cannot be depended upon to do this under the influence of, say, 70° C. and a moderately high pressure. As regards dielectric strength, paper 6/32-in. thick, of the ordinary quality used, withstood a pressure of 18,000 alternating volts.

The specific inductive capacity of paper is less than half that of rubber. This is an important item, because the energy loss due to the capacity of the line is directly proportional to the specific inductive capacity of the insulation between the conductors. Several years ago the New York Edison Co. made some tests of the losses in paper and rubber insulated cables, with the following results:

Dielectric Losses in Triplex Cables Operating at 6,400 Volts—25 Cycles.

	Paper cable.	Rubber cable.
Length, ft.	10,935	24,756
Copper, cir. mils.	250,000	250,000
Insulation	10/32-in	10/32-in.
Temperature (about)	80° F.	80° F.
Charging current in amperes, working conditions	0.47	2.16
Total watts lost	312.6	4295
Watts lost per ft.	0.02859	0.1723

The above figures show a decided advantage in favor of the paper insulated cable.

It has been suggested that the ideal cable would be one made with a combination of rubber and paper. Such cables have been made and have failed, as they combined the disadvantages of the two kinds of insulation as well as their advantages.

Up to 1895 rubber cables were used almost exclusively. About that time paper cables were put on the market. They were regarded with suspicion at first, probably on account of the fact that they appeared to be cheap substitutes, and were consequently little used. However, they were gradually installed as experiments, and, proving reliable, they have entirely replaced rubber cables on many large systems. The New York Edison Co. may be taken as a typical case. This company put in a few paper cables in 1899. The installation proved so successful that since that time no rubber cables have been installed by this company, except in a few places where the cables are subjected to mechanical injury or other exceptional conditions.

SUMMARY.—A consideration of the above leads to the safe conclusions that neither kind of insulation is perfect; that each has both good and bad qualities, and that in a given case the success or failure of a cable depends upon the care used in the design and manufacture and upon the service conditions. Since paper cables are cheaper in first cost than rubber, and will last as long as the sheath remains intact, they are undoubtedly better in places where there are no grounded direct-current trolley systems, or where the electrolysis caused by such systems can be eliminated.

NEW DEPOSITS OF MAGNESITE in California have led to the erection of a factory at East Oakland, Cal., for the manufacture of magnesite brick. Magnesite finds its most important use as a material for making refractory brick for lining cement kilns and smelting furnaces which carry basic slags. The magnesite brick made in this country has, up to the present time, been manufactured in Pennsylvania out of magnesite imported from Greece or from Austria, which has been cheaper than magnesite brought to the furnaces from California. It remains to be seen whether the steel manufacturers will find it cheaper to transport the California brick or buy Pennsylvania brick made from imported magnesite.

PARABOLIC REINFORCED CONCRETE ARCH BRIDGE AT WABASH, IND.

The highway bridge illustrated in the accompanying drawings is noteworthy for the rather unusual curve of the arch ring, a parabolic arc, and for the complete reinforcement of the spandrel walls. The use of the special bar form for the reinforcement also gives a rather remarkable arrangement of metal in the arch ring. The designers claim especial merit for this, namely, that the diagonal members, being integral with the extradosal and soffit bars and interlacing across the ring depth, so tie the concrete together as to give the effect of lattice girders and so anchor the main bars that they do not straighten out under stress.

The bridge, which crosses Charley Creek, near Wabash, Ind., is 240 ft. long over all, and has a width of 32 ft. over all. It is made up of two 75-ft. arches of 18 ft. rise, carrying solid spandrel walls with earth filling between. The drawings of Fig. 1 show the arch and spandrel construction in longitudinal and transverse section. The arch ring was designed in accordance with the method of calculation devised by the late Prof. Charles E. Greene, of the University of Michigan, and described in his book on arches. The curve of the intrados is a parabola. The arch ring is 18 ins. thick at the crown and 3 ft. 4 ins. at the haunches. It is reinforced with Kahn trussed bars, arranged one above the other in pairs, so that their diagonals interlace across the depth of the arch ring. The lengths of the several bars and their cross-sectional dimensions are clearly shown by the drawings. Crosswise of the arch ring are a number of ¾-in. round rods, inserted to resist temperature stresses.

The bridge, as described, was designed and built by the Trussed Concrete Steel Co., of Detroit, Mich.

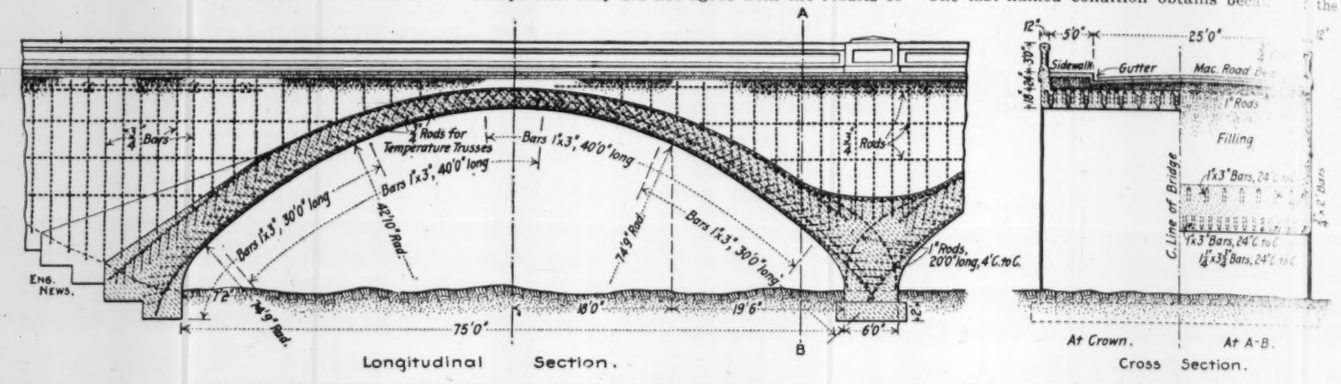
THE DESIGN OF CONCRETE-STEEL BEAMS AND SLABS.

By Edward Godfrey.*

The formulas for proportioning concrete-steel beams are legion, and they are far more varied than those for the design of columns with which engineering literature was flooded a decade or two ago. Nice formulas for the design of columns were elaborated in the days before tests were so common that were satisfactory in every respect, except that they did not agree with the results of tests that were subsequently made. Investigators later found that the behavior of compression members of practical proportions agreed very closely with a simple little straight line formula. Even at the present time the last of these complex formulas has not been weeded out of specifications.

Another feature of construction that has yielded to the simplifying influence of development, or the developing influence of simplification, relates to the ultimate and the working stress of steel. The two grades of structural steel, with separate unit stresses, though they are still recognized in some specifications, are gradually merging into one grade for all pieces subject to the ordinary processes of the shop, excepting forging; and the manufacturer no longer needs to exhibit his ability to bring forth either grade from the same melt, bloom, billet or finished piece.

Concrete-steel designing is young, and probably on account of its rapid growth the infant is afflicted with both of the above-named ailments. The formulas brought out rival those for retaining walls in complexity, and the units



F.G. 1. SECTIONS OF REINFORCED CONCRETE ARCH BRIDGE OVER CHARLEY CREEK, WABASH, IND.

real but uncertain element of strength imparted to the combination of concrete and steel by the strength possessed by the steel after it has passed its elastic limit, the nominal limit of ultimate strength.

There are many kinds of concrete, just as there are many grades of oak. Some oak has knots and wind shakes and is unfit for use in a structure, but specifications for oak beams do not recognize these grades in allowing unit stresses: rather the aim is to exclude those grades unfit for use by proper selection and inspection of the materials. So in concrete-steel construction there should be a standard, and this should be a concrete suitable for the purpose and made strictly according to the requirements, as near as these ends can be accomplished commercially.

It is almost universally agreed that concrete composed of 1 part Portland cement, 2 parts sand and 4 parts small hard broken stone or gravel, or of proportions closely approximating these, is the most suitable mixture for the concrete. For cinder concrete the same proportions, using cinders in place of broken stone, may be called

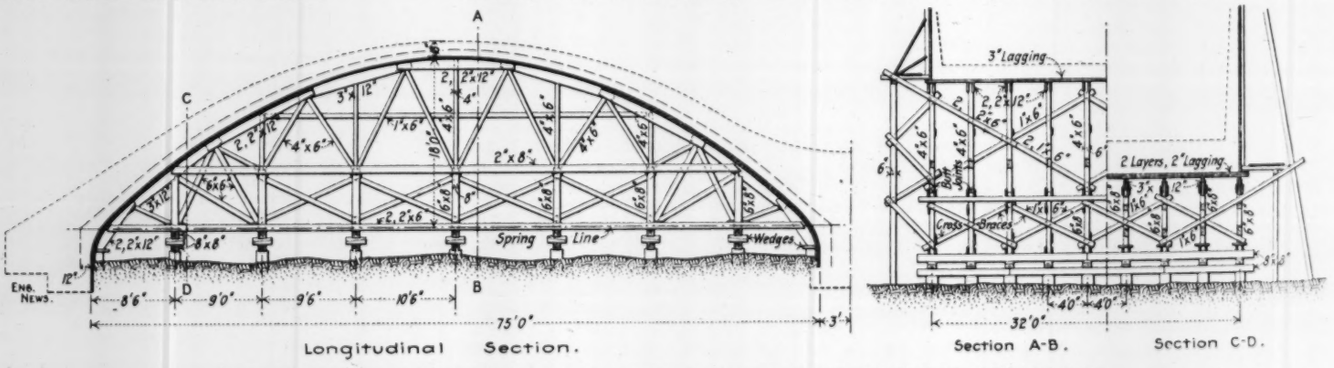


FIG. 2. CENTER AND SPANDREL WALL FORMS FOR CHARLEY CREEK BRIDGE, WABASH, IND.

The spandrel walls were designed as vertical cantilever slabs. Their reinforcement consists of trussed bars set upright, as shown, and of round longitudinal temperature bars. Other details of the reinforcement that deserve notice are the bonding together of the arches and spandrel walls over the center pier.

The arches and spandrels were constructed on the centers, shown by Fig. 2. The concrete mixtures used were a 1-2-4 stone mixture for the arch ring and a 1-2½-5 stone mixture for the spandrel walls and foundations. The mixture was made very wet.

recommended are about as numerous as the formulas.

The foregoing may seem an inconsistent preface to a paper suggesting both formulas and unit stresses, but the writer's purpose is to show the busy engineer, who does not want to delve into abstruse mathematics, that formulas for the design of concrete-steel beams or slabs can be made as simple as those for steel beams. In fact, the formulas are even more simple than formulas for steel in bending, if certain rules of proportioning be adopted. Further, the agreement between the formulas and the actual [illegible] the construction is about as close as [illegible] struction, as many tests closely ap[illegible] the proportions here recommended h[illegible] strated.

In the matter of variation from an[illegible] unit stress we commonly allow st[illegible] about 8% either way from a desired a[illegible] sile strength. We should be satisfied [illegible] steel tests show as close agreement [illegible] calculated strength, especially as the[illegible] barring the effects of careless work, [illegible] ably be on the safe side in nearly e[illegible] The last-named condition obtains beca[illegible]

standard. It is also common knowledge that this stone concrete, when made of good materials, will sustain an ultimate crushing load of about 2,000 lbs. per in., and the cinder concrete will take about 750 lbs. per sq. in. It is presumed in all cases that the materials and workmanship are good, just as we presume that wood used in structures is good and sound.

It is further almost generally agreed that the ultimate strength of a concrete-steel beam is reached when the steel is strained to its elastic limit and the concrete has reached its ultimate strength.

*Monongahela Bank Building, Pittsburg, Pa.

[illegible] of steel having high elastic limit and [illegible] upon high safe units in consequence [illegible]ible. The excessive stretch in the steel will [illegible] the concrete. The writer made a number [illegible]s on the floors of a large concrete-steel [illegible]rd in one case, in a bay containing 13 [illegible] cracks were counted in the beams [illegible] "safe" load was placed upon the floor. [illegible] had 16 cracks. Many of these appeared [illegible]fore the supposed safe load was placed. [illegible]flection was excessive. This building was [illegible] with steel of high elastic limit, and [illegible]ence was placed upon the high tensile value [illegible] steel to sustain the loads.

The theoretic elongation of the concrete, even at moderate tensile values in the steel, corresponds to excessive tensile values in the concrete; and the fact that concrete in which steel is embedded has been stretched out in tests without cracking to elongations that would rupture plain concrete is evidence that the concrete in setting has shrunk, thus putting the steel under an initial compression, which must be overcome before any stretch occurs in the concrete. This shrinking of concrete in setting is one of its most useful properties, viewed as a medium in concrete-steel construction. Besides giving the embedded steel an initial compression and thus helping its tensile value, it also grips the steel, and thus takes firm hold upon it, greatly aiding the adhesion of the concrete to the steel. It is to be noted that this gripping of the steel, and not mere adhesion due to contact, is the thing that makes the union between the steel and the concrete effective. This is the reason why round and square bars hold better in the concrete than flats. It is also a reason for bedding the steel deep enough from the surface of the concrete to make the gripping effective. It further overcomes the almost infinitesimal reduction in diameter in the embedded steel when under stress below the elastic limit, so that the adhesion or skin friction is not lost when the steel elongates slightly.

The fact that concrete shrinks in setting further points out the error in depending for compression upon steel embedded in concrete, unless the concrete is merely used for its protecting value. The initial compression in the steel adds an uncertain amount to any calculated compression in the same. Steel reinforcement in the intrados of segmental concrete floor arches is not rational design, as the steel, to be useful, must be in compression. Steel embedded in concrete columns as hoops or spirals is rational, as loading the column tends to increase its diameter and to put tensile stress in the steel. Also light longitudinal rods, wired to these spirals to take flexure in the columns, is excellent to reinforce the column against eccentric or lateral forces.

Another phase of this shrinking is that very long units in concrete-steel construction should not be placed at one time, unless expansion joints be provided. It is the shrinking of concrete that causes vertical cracks in plain concrete walls to appear at intervals, and makes it expedient to leave expansion joints in such walls 30 ft. apart or so. Steel embedded in concrete walls or other construction has the effect of distributing the shrinkage stresses and lessening the shrinkage cracks, and walls thus reinforced can be made much longer without liability to these cracks than plain walls. However, if a long reinforced wall is brought up uniformly from the ground up, shrinkage cracks will probably appear. If the wall be built from one end to the other, allowing setting and shrinking of part of the wall before the remainder has been placed, a very long wall can be made without danger of these cracks. By the same token long concrete-steel buildings should be placed in alternate units, if much is to be finished at once, leaving the intermediate units to be placed after the setting of the first; or some other provision should be made to allow for the shrinkage of the concrete.

It is not the intention here to go into the subject of the making of concrete, more than to say that it is absolutely essential in this class of work that the concrete be thoroughly mixed, and it should be very wet. Dry or mealy concrete is totally unfit for concrete-steel work. It will neither adhere to the steel nor protect it.

Tests show that a rod embedded in wet concrete will resist pulling out, when the concrete has set and hardened, with a force of about 500 lbs. per sq. in. of the surface of rod embedded. At 10,000 lbs. per sq. in. on the steel and 50 lbs. per sq. in. adhesion to the concrete a round or square rod should be embedded 50 diameters in concrete. This is very often ignored in concrete-steel beams designed for buildings and prepared for test. The curve of maximum moments of a beam taking uniform load or a single rolling load is a parabola; hence the curve of stress in the reinforcing rods, assuming them to be parallel to the bottom of the beam, is a parabola. The line representing the adhesive value of a rod embedded in concrete is a straight line from the end of rod to the point of maximum stress; hence for the adhesive value to be at all sections greater than the actual stress the straight line should be outside of the parabola; that is, it should be tangent to it at the support. This would make the ordinate of the straight line just twice that of the parabola, or the adhesive value should be double the maximum stress. Therefore, it is essential in consistent design to have the beam no less than 100 times the diameter of rod from end to center of span. In other words, the rod should be no more than 1-200 of the span length.

Tensile value of the concrete should not be allowed under any circumstance, as one shrinkage crack may destroy entirely this tensile value for the whole beam.

As intimated, high tensile strains in the steel, though they may be warranted from the standpoint of high elastic limit in the material, presume too far upon the extensibility of the concrete. The elastic limit of ordinary structural steel, or 40,000 lbs. per sq. in., is the most suitable value to represent the ultimate useful strength of the steel. With 2,000 lbs. per sq. in., as the ultimate strength of the concrete in compression, and with tension eliminated there remains the variation of the stress in the concrete from the neutral axis up and the position of the neutral axis to determine the value of the beam in flexure.

Tests have shown that the neutral axis of a concrete-steel beam remains close to the middle of the depth of the beam. A little calculation will show that a variation of one-eighth of the depth of beam one way or the other, in the standard construction here to be proposed, makes a difference of about 6% in the calculated resisting moment, if the stress in the steel remains the same, or about the same difference if the extreme fiber stress in the concrete remains the same. Using the units heretofore given and 2,000,000 as the modulus of elasticity of concrete, and substituting in one of the elaborate formulas, which allows for parabolic variation of the stress in concrete from the neutral axis both ways and for tension in the concrete, the neutral axis is found to be within 4½% of the middle of the depth of the beam. So that the neutral axis is shown, both by theory and test, to be close to the middle of the depth of the beam, and its shifting a comparatively large fraction of the depth makes but small variation in the calculated strength of the beam.

The assumption that the variation in stress in the concrete from the neutral axis to the extreme fiber is according to a curve deviating somewhat from a straight line is another element that complicates the formulas. Here, again, fine theory arrives at conclusions that are incompatible with the known variations in ultimate compressive strength of different tests made of the same materials under apparently the same conditions. To assume that the intensity of stress in the concrete varies directly as the distance from the neutral axis is sound engineering and is accepted by many investigators.

In order to simplify further the calculations, it is recommended that the center of the steel be one-eighth of the depth from the bottom of the beam.

Referring to Fig. 1, it is seen that the total compression in the concrete is $2{,}000 \times \frac{BD}{4} = 500\ BD$. This must equal the tension in the steel. Now, if the area of the steel be A, we have $40{,}000\ A = 500\ BD$, or $A = 1.25\%$ of the rectangle BD.

The center of gravity of the stress in the concrete is $\frac{2}{3} \times \frac{D}{2}$ or $\frac{1}{3}$ D above the neutral axis, and the effective depth of the beam is $\frac{1}{3}D + \frac{3}{8}D = \frac{17}{24}D$.

The ultimate resisting moment is $\frac{17}{24} D \times 500\ BD$, or $M = 354\ BD^2$.

Assuming all dimensions in inches, this moment is in inch-pounds. Or, making B = 12 and dividing by 12 to reduce to foot-pounds, we have ultimate bending moment in foot-pounds per foot in width of slab or beam = $354\ D^2$.

Now as to the shear. It is safe to say that any stone concrete that will not stand 50 lbs. per sq. in. as a safe load in shear should not enter into

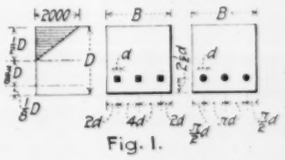


Fig. 1.

the construction of concrete-steel beams and slabs; also that concrete should not be stressed much above this amount in shear. The horizontal shear in the beam in a section just above the rods is equal at any point to the increment of stress in the rods. Hence, as we have used the same unit for shear and adhesion, there should be the same area across the beam as that of the surface of the rods. Round rods should then be spaced not less than π or 3.1416 times their diameter apart and square rods not less than four times their diameter apart; also the distance to the side of beam at last bar should not be less than one-half of these respective distances. With rods spaced just these amounts, it will be found that the distance from center of rod to bottom of beam will be 2½ times the diameter of rod, which is an ample depth to insure gripping of the steel by the concrete. Of course, rods can be given wider spacing than that shown in the figure. For example, square rods spaced five times their diameter apart will be two diameters from the bottom of beam.

This limit in the spacing of rods is very often overlooked in the designing of beams for buildings and for test. The beams are made too narrow and unscientific expedients are resorted to to overcome the defect. This has even more force in the case of dependence upon high tension steel or mechanical bond, as the greater increment of stress that must be assumed demands greater area of concrete to take the horizontal shear.

Again, in the matter of vertical shear at the end of span. Assuming a safe bending moment as one-fourth of the $354\ D^2$ already found, and equating to the expression for the bending moment in a uniformly loaded beam at W lbs. total load, we have

$$\frac{W\ L}{8} = 88\ D^2 \quad (L = \text{span in feet}).$$

But the allowed end shear at 50 lbs. per sq. in. on a rectangle 12 ins. wide and D ins. deep, remembering that the maximum intensity of shear in a rectangular beam is three-halves of the average, is

$$\frac{W}{2} = \frac{2}{3} \times 50 \times 12\ D,$$

or total allowed load on beam = $W = 800\ D$.

Substituting this value of W in the equation above, we have

$$D = \frac{100}{88} L.$$

But, as D is in inches and L is in feet, the actual ratio is very close to 10. Hence, when the depth is more than one-tenth of the span, the

full load on a beam begins to overtax the shearing strength of the concrete before the steel reinforcement has its proper stress. Here again some investigators have erred by making short, deep test beams; and, finding that they fail in shear, concluding that concrete is inherently unreliable in shear; whereas the real fault is in the design of the beam.

In all concrete-steel designing more or less reliance must necessarily be placed upon the shearing strength of the concrete. It only remains to proportion the beam or slab in such way as to place the concrete where it will take the shear. The best mechanical bond can do no more than transmit the forces of shear in concrete into direct stress in the steel or direct stress in the steel into shear in the concrete. It is difficult to see how stirrups placed at intervals could perform this function.

From Fig. 1 it is seen that the maximum depth of beam is 20 times the diameter of rod. Hence the maximum ultimate bending moment is

$$354\ D^2 = 354 \times (20\ d)^2 = 141{,}600\ d^2.$$

But the minimum span must be 200 d to develop the adhesion in the rod. This is 10 times the depth, which agrees with the limiting span for shear. Since the shorter the span the greater the load per square foot for the same resisting moment, we may obtain the limiting load per square foot thus: The moment in foot-pounds on a span 200 d ÷ 12 ft. long is $\frac{w}{8}\left(\frac{200\ d}{12}\right)^2$, where w is the load per square foot. Equating this to 141,600 d^2, we have w = 4,080.

This is the maximum ultimate load per square foot that can be placed upon the top surface of a concrete-steel beam of stone concrete designed in the proportions here given and with the units here employed.

For cinder concrete, by the same course of reasoning, using 750 lbs. per sq. in. ultimate compression and 30 lbs. per sq. in. for adhesion and shear, we arrive at the following results:

Maximum ultimate bending moment = 133 D^2.
Minimum span for adhesion = 333 d, or 6.26 D.
Percentage of steel reinforcement = .47.
Minimum span for shear = 6.65 × depth.
Maximum ultimate load per square foot = 3,910 lbs.

It is recommended that for quiescent loads as in buildings a factor of safety of 3½ be used, and for rolling loads a factor of 4. The minimum span lengths, or, in other words, the maximum depths, should be used only in extreme cases. In special cases, where the beams would be clumsy, some of the rods may be curved up and anchored at the ends, thus making suspension rods receiving all of their stress at the ends. A rod thus placed in a curve would carry the shear corresponding to its own tension, leaving the concrete to take only that due to the transference of stress into the horizontal rods.

Fig. 2 shows the proportions for a beam of this design. The end detail of the rod should be capable of taking practically all of the stress on

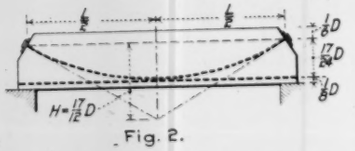


Fig. 2.

the rod; upsetting would not be necessary, however. Turning up rods at the end without anchoring the ends or making them continuous can scarcely be said to add any useful element of strength.

The shear carried by the curved rod will be found to be equal to the stress in the rod times H ÷ ½ L.

For slabs of short span the rules of design here given would demand close spacing of steel of small diameter. Steel mesh is the most suitable material, if the strands are straight; or if wires or rods are used, alternate strips of the slab may be considered as beams supporting strips of plain concrete between, which act as fillers, or which may be considered to perform the useful office of absorbing shock.

As an example of the application of the foregoing, given a floor with beams spaced 5 ft. and having a span of 20 ft. and these beams carried by girders of the same span; all to carry 100 lbs. per sq. ft. of live load, considered as quiescent. Assume a depth of slab of 4 ins. and 3 ins. spacing of rods. The rod will be ⅛ of the depth, or ½-in. from the bottom of the slab. The safe bending moment on the slab per foot of width, with the full area of the steel, would be 101 × 16 =

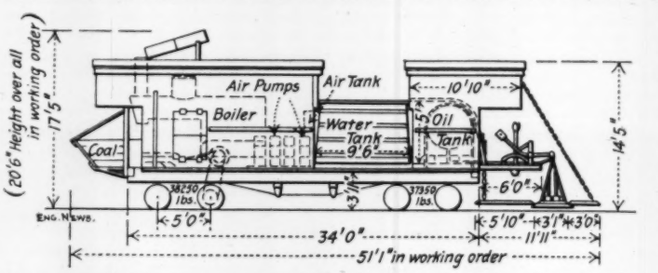


FIG. 1. WEED-BURNING CAR; MINNEAPOLIS, ST. PAUL & SAULT STE. MARIE RY.

1,616 ft.-lbs. But the total moment, including 50 lbs. per sq. ft. for weight of slab, is 150 × 25 ÷ 8 = 469 ft.-lbs. Hence in 3 ins. only $\frac{469}{1616}$ of the steel area is needed. Now, 1¼% of 3 × 4 = .15 sq. in., and the fraction of this required is .044 sq. in. One-quarter-inch round rods will therefore suffice. One-two-hundredth of the span is .3 in. and the diameter of rods is less than this, as it should be. For the beam, assume a depth of 20 ins. This includes the depth of slab. Taking the dead load at 95 lbs. per sq. ft., the total moment is 5 × 195 × 20 × 20 ÷ 8 = 48,750 ft.-lbs. The allowed moment on the beam per foot of width is 101 × 20^2 = 40,400 ft.-lbs. The width of beam should therefore be 1.21 ft., or 15 ins. Rods will be 2 ins. from bottom of beam, and the area required is 1¼% of 300 = 3.75 sq. ins. Three 1⅛-in. square rods will satisfy the conditions. The maximum diameter of rod allowed = $\frac{1}{200}$ × 240 = 1.2 ins.

For the girders, assume a depth of 32 ins., including the depth of slab. Using a dead load of 120 lbs. per sq. ft., the total maximum moment is 220 × 20 × 20^2 ÷ 8 = 220,000 ft.-lbs. The allowed moment per foot width of girder is 101 × 32^2 = 103,430 ft.-lbs. The width of beam required is then 25½ ins. The area of rods required is 1¼% of that of the beam, or 10.2 sq. ins. This is very nearly made up by six rods 1¼ ins. in diameter and two 1 5-16 ins. The allowed safe shear on the full section of the concrete girder is ⅔ of 200 (the nominal ultimate) ÷ 3½ (the factor of safety), or 40 lbs. per sq. in. The concrete will then take 40 × 32 × 25.5 = 32,640 lbs. The total end shear is 44,000 lbs. As the concrete will take just about ¾ of the shear, we may turn up the two 1 5-16-in. rods and anchor them at the ends, as in Fig. 2. The stress in these rods will product of their area and 2-7 of 40,000 lbs. The shear that they will carry is the method given under Fig. 2 to be 11 which is just about the amount needed to ment the shearing strength of the concre diameter of the horizontal rods is just more than 1-200 of the span length, and can be spaced a little more than π or times their diameter apart. The two curv may be placed horizontal rods, a give rise to no hor shear in the concre latter merely hang them as a saddle.

In a beam of the proportioned some of steel could be by placing the rods er to the bottom of beam, or, say, 3 ins. from the same, and making their area inversely proportional to the distance from neutral axis.

The writer believes that the foregoing principles of design, while they do not show the apparent economy of some special systems, would place concrete-steel designing in the class of sound engineering and force recognition where it is now decried.

Tests of beams thus systematically designed would show where any modification of units is needed.

RAILWAY WEED BURNING DEVICES.

On many railways, and especially the Western prairie lines, the keeping of the tracks clear from weeds is a difficult problem, as the section forces are limited and the growth of weeds is very rapid. In several cases cars fitted with oil burners, making a hot flame beneath a pan or apron, have been used with success, and one of these is illustrated herewith. The first machine was built at the Shoreham shops of the Minneapolis, St. Paul & Sault Ste. Marie Railway about ten years ago, and we are informed by Mr. T. A. Foque, Mechanical Superintendent, that if another was to be built there would be no change in the burners and effective parts. Blue prints have been sent to a number of other railways, which have copied the machine, with certain modifications or improvements of their own. Fig. 1 is an outline drawing, showing the general construction, and the view in Fig. 2 shows the arrangement of the apron and burners.

The machine consists of a flat car, upon which are mounted a horizontal return-tube boiler and a Brownell engine, with cylinders 11 × 18 ins., making the car self-propelling by means of a sprocket-chain to one of the truck axles. The boiler also supplies steam for operating four 6-in. air pumps and a duplex pump. At the other end of the car are a wooden water tank of 3,000 gallons capacity, and an oil tank of 981 gallon capacity. At the extreme end is the operating platform, from which the set of 12 burners is suspended, being attached to a swinging frame operated by a lever, so that they can be raised to clear obstructions. Sheet iron aprons extend in front and behind the pan of the burners. The speed at which the machine is run depends altogether upon the nature and growth of the weeds. When the weeds are light one burning will kill them. On this road the common forms of prairie weeds (including much Russian thistle) have to be dealt with, and when

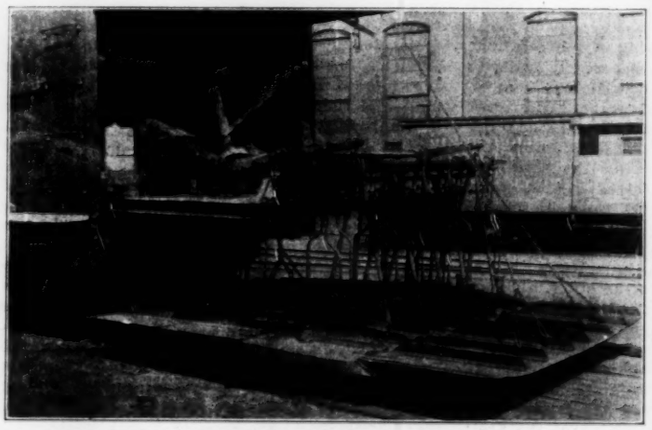


FIG. 2. OIL BURNERS AND APRON OF WEED-BURNING CAR.

they [illegible] heavy it is necessary to make two runs over [illegible]. The oil consumed averages about 31 gallons per mile of weeds burned. The machine weighs 75,600 lbs. in working order.

An apparatus for utilizing the smokebox gases from locomotives to destroy weeds (D. Hawksworth patents of 1885-'86) was in use at one time on the Chicago, Burlington & Quincy Railway lines west of the Missouri River. This is shown in Fig. 3, from blue prints furnished by Mr. F. H. Clark, General Superintendent of Motive Power. This device did not prove satisfactory, however, and recently a weed-burning machine, using fuel oil (on the same general principle as the machine already described), has been built. In the Hawksworth system a cylindrical chamber in front of the smokebox terminated in a vertical chamber 8 ins. wide, extending across the track. In front of this was a short apron, resting upon the rails. Within the chamber were two steam jets, supplied by a pipe from the dome. When the engine was in use as a weed-burner the smokestack was closed by a damper and a valve turned in the exhaust nozzle so as to discharge the exhaust horizontally.

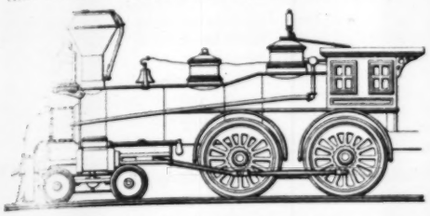


Fig. 3. Locomotive Fitted to Apply Smoke-Box Gases for Weed-Burning; Chicago, Burlington & Quincy Ry.

THE RELATION OF SEDIMENTATION AND ACID MINE WASTES TO THE POTABILITY OF THE LOWER MONONGAHELA RIVER.

By S. J. Lewis.*

During the summer of 1905 the writer, acting for the U. S. Geological Survey, conducted investigations of water supply conditions on the Monongahela River. This stream has a quick-spilling drainage area down to Greensboro, below which it is completely canalized and the current is very sluggish. This is coincident with a rapid increase in the density of population draining into the stream. The river receives the sewage of nearly 200,000 people, besides an enormous amount of industrial waste, in the 80 miles between Greensboro and Pittsburg. The greater part of the population is located immediately on the river banks, and its sewage is discharged directly into the stream.

The combination of sewage, mine-waste and mill-waste with a naturally muddy water cannot by any stretch of the imagination be considered fit for drinking. Nevertheless, nearly every town on the stream is supplied with raw river water, and the belief is general in this section that this water is safe and wholesome for drinking. This belief springs from two features peculiar to the locality:

(1) The stream is for much of the year so completely without current that many think the sedimentation thus afforded will rid the water of all impurities. (2) It is thought that the large amount of acid industrial wastes exercises a powerfully germicidal effect on the disease bacteria that may be in the water.

SEDIMENTATION OR DETENTION INADEQUATE FOR THE REMOVAL OF IMPURITIES FROM MONONGAHELA RIVER WATER.

It is accepted that sedimentation in properly constructed reservoirs is beneficial to polluted waters. That such sedimentation is not by itself a substitute for purification should be as widely known. The river water which caused the Lawrence epidemic of 1891 had been two weeks in storage before it was supplied to consumers. The public supply at Covington, Ky., using the badly polluted Ohio River water, is from a storage reservoir where this water is kept 32 days before use; yet the town suffers heavily from typhoid fever, most of it not traceable to other sources. At New Albany, Ind., with a month's storage of the supply, similar results are noted. No engineer would claim that sedimentation alone will improve a badly polluted water so that it can be used with entire safety.

The beneficial influence of sedimentation depends almost wholly upon the amount of time that is given for the quiescent water to settle in a basin. This time element is absolutely necessary. The use of the term "sedimentation" seems, therefore, somewhat unfortunate. It is proposed to substitute for it the term "detention," as adequately expressing the time relation that is the prime factor in the purifying process. Detention, then, is the process of keeping a water as nearly motionless as possible for as long a time as possible. It is quiescence plus length of time, and its efficiency will evidently be inversely proportional to the rate of motion of the water; or

$$\text{Detention} = D = \frac{1}{V}, \text{ where } V = c\sqrt{r\,s},$$

the latter being the well-known Chezy formula for the computation of flow in open channels. If by its use the velocity be determined as 2, 3, etc., cu. ft. per sec., then D in the formula will have fractional values for streams with such velocities. In streams having either no current or no obstructions this relation should be directly determinable. Evidently, with an appreciable velocity, the detention is fractional, and the opportunity for self-purification correspondingly small. The value of V that need at this time be considered is zero, which, substituted in the formula, gives a value of infinity for D. A condition of absolute quiet is therefore necessary for perfect detention. This condition is not even approximated in the best storage reservoirs. The influences of wind, temperature, inflow and outflow all combine to maintain a certain degree of motion. In order that nearly perfect detention shall be approximated on a running stream there must be practically no current at any time; as at low water the Monongahela River is a chain of stagnant pools totalling 80 miles in length, conditions seem to be highly favorable for detention. Let us see if this is actually the case.

If the contamination in this stream were supposed to enter only at Greensboro and ceased below that point, it seems more than probable that the water would, in the 80 miles of detention, be satisfactorily purified by the time it reached Pittsburg—if it ever *did* reach Pittsburg. The average citizen seems unable to appreciate the fact, which seems also to be overlooked by engineers, that contamination not only does not cease at Greensboro, but grows greater in quantity and more offensive in quality with every foot that one goes down the river. Instead of the pollution being a certain fixed amount which is subject to the infinitely high detention influence of 80 miles of stagnant water, the contamination is scattered along the entire stream. For example, the sewage of Charleroi, with a population of 7,000, goes into the river, to be pumped raw by Monessen, only a few miles below, and distributed through the pipes of the city before the river has had the water more than a few hours. The effect of the use of this water on the health of Monessen is evident from the following figures of typhoid mortality.*

Typhoid Fever Mortality, Monessen, Pa.

Year.	Total deaths.	Typhoid cases.	Typhoid deaths.	Percentage total mortality.
1900	30	50	10	33
1901	60	17	4	6.6
1902	75	..	9	12

When it is considered that there are about 30 towns in the United States in which the typhoid death rate is less than 25 per 100,000, corresponding to a mortality of about 1%, the significance of these figures becomes sinister. It is possible that some of the deaths were of foreign origin,† as the number of cases is decidedly less than that usually allowed by epidemiologists (ten cases per death). The fact that a majority of the cases were traceable to the use of the city water puts the responsibility for this condition clearly where it belongs. If the river could take all the pollution at a certain point and give 80 miles of detention to it, the resulting water might be drinkable. But such is not the case. Each pool has its own contamination, and must do its own purifying. The detention efficiency of the river is measured not by its absolute length—again the old error—but by the time that each batch of pollution gets in detention; in other words, it is measured by the efficiency of the last pool above the particular town whose water supply may be under discussion. The case of

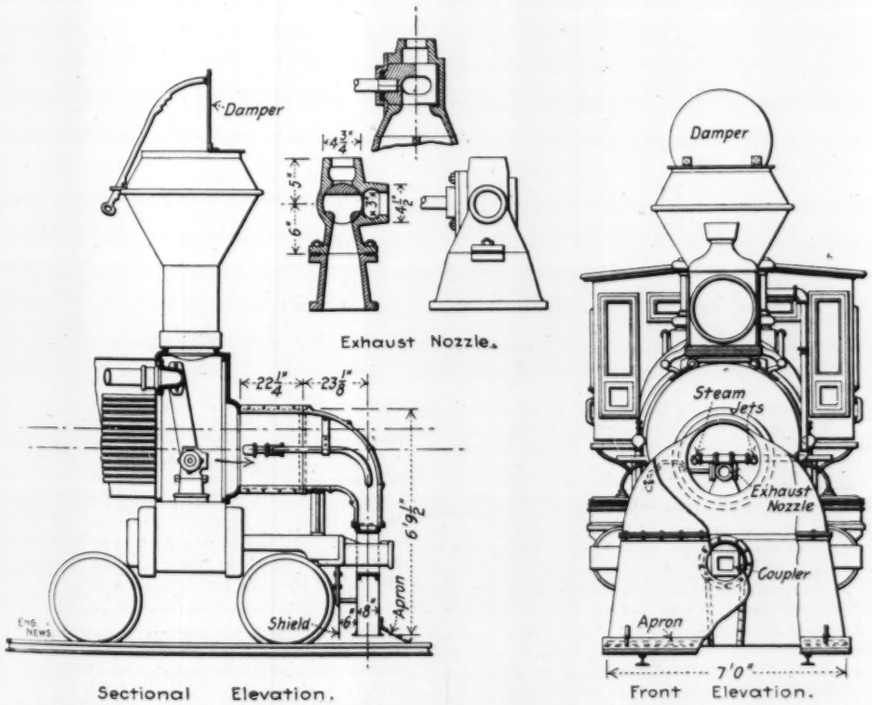


FIG. 4. LONGITUDINAL AND CROSS-SECTIONS OF FRONT OF WEED-BURNING LOCOMOTIVE.

*Assistant Engineer, U. S. Geological Survey, 958 Prospect Ave., New York City.

*The majority of these cases were visited by the Medical Inspector of Washington County, Pa., and traced to the use of the river water. Report Pa. State Board of Health.

[†Or that not all the cases were reported.—Ed]

Monessen is bad; the case of McKeesport is worse, because there are more people affected.

Typhoid Fever Mortality, McKeesport, Pa.*

Year.	Population.	Total deaths.	Typhoid cases.	Typhoid deaths.	Per cent total mortality.
1893	27,000 (est.)	464	123	..	...
1894	28,000	454	63	8	1.8
1895	28,000	444	299	29	6.5
1896	30,000	537	144	13	2.4
1897	30,000	468	86	8	1.7
1898	33,000	528	100	15	2.8
1899	33,700	589	151	14	2.4
1900	34,227	684	315	23	3.3
1901	35,000	693	275	29	4.2
1902	35,500	799	282	30	3.8
1903	36,000	788	313	43	5.5
1904	37,000	796	324	48	6.0

*Report McKeesport Board of Health, 1904.

The last year's figures are equivalent to 129 deaths per 100,000—a figure putting McKeesport in the same class with Wheeling, W. Va., and Pittsburg, Pa., as a hotbed of the disease. Can anyone claim that a water supply whose use results in such disease can be other than contaminated?

If there is any cumulative effect in the chain of pools, that is, if each pool, after purifying its own sewage, has some residual purifying power to apply on matter from above—a paradoxical condition—the river water near Pittsburg, at the end of the long chain, should be of excellent quality. The figures below are quoted from an article in Engineering News, appearing in 1904. They show that Monongahela River water supplied to the south side of the city and to six boroughs of the city proper give the following results on the health of the consumers:

Typhoid Fever in Part of Pittsburg, Pa.
Deaths per 100,000.

1898	1899	1900	1901	1902	1903
71	110	144	125	144	139

These figures are so much worse than McKeesport's as to make it certain that the river water has not improved in the travel between the two cities; in other words, each pool has not sufficient time to purify its own sewage, so that the accumulations from above are passed on practically unchanged. The theory of an 80-mile detention basin is very pretty, but in this instance it does not work out.

It must not be forgotten that to have the pollution settle to the bottom is by no means to get rid of it. Disease-producing bacteria can live either with or without oxygen, and may retain vitality for an indefinite period in the material at the bottom. If, through a sudden rise in the velocity of the stream, scouring should take place from the sedimented material, it might largely be returned to the main body of water, to be swept into water supply intakes below, as in the epidemic of typhoid at Detroit, caused by the removal of sewage deposits from the bed of a river ultimately delivering into the water supply of the city. It is true that typhoid and coli forms degenerate markedly within a short time of their entering large bodies of water, but so many epidemics have arisen from germs washed into reservoirs, where they must have stayed for some time, that it seems more than possible for disease to originate from pathogenic organisms which have been stored at the bottom of a detention basin. In the case of the Monongahela such masses of material may be and are swept down stream every spring by violent floods. Measurements by the U. S. Geological Survey show* that in the spring the river may rise within a few hours, and sometimes three or four times a month, from 7,000 or 8,000 cu. ft. per sec. to the enormous figure of from 45,000 to 200,000 cu. ft. per sec., an expansion in the fixed channel of from 6 to 25 times the original volume of water. During several months of the year, therefore, detention would be useless, on account of the scouring; the rest of the year there is so very little water, as compared with the greater summer pollution, that it is hopeless to expect the water to become even reasonably safe.

THE GERMICIDAL EFFECT OF ACID MINES WASTES ON PATHOGENIC GERMS IN THE MONONGAHELA RIVER WATER.

There remains for discussion the theory that enough mine wastes enter the stream to be germicidal to bacteria, yet harmless to water-users. Most of the washings from coalfields enter by way of the Youghiogheny River at McKeesport, so that the portion of the stream above this city would be ruled out at once. The acid drainage above this point is mainly from mills. Field tests made by the writer have failed to show that the acidity of the water is sustained more than a mile or two below the mine outfalls.

Acid wastes enter the river mainly as sulphate of iron. Free acid sometimes occurs, usually in small amount. There is also much lime in the water. Such purifying action as goes on is due to the combination of these chemicals to form bulky precipitates, which settle to the bottom in quiet water; in going down they entangle much suspended matter, so that at times the water may be improved 50% to 95%. The process is merely a rough approximation to the coagulating processes in extensive use in mechanical filter plants. In chemical action it is practically identical with the methods in use at Lorain, O., Quincy, Ill., and St. Louis, Mo. Experience with the muddy and highly colored water of this section has shown conclusively that the process is absolutely necessary for the economical treatment of these waters. It is the unanimous opinion of engineers, however, that such a process cannot be regarded as adequate in itself to assure the safety of a polluted water. After-filtration is necessary, if only to remove the precipitated organic matter.

The treatment at St. Louis is typical. At this place coagulation is all the treatment the city water gets. The percentage of removal of bacteria frequently rises to 98%, and frequently drops to 75% or less. The average of figures for a number of months in 1904, submitted by the city bacteriologist,* is a little over 94%. This is looked upon with considerable satisfaction, because mechanical filters frequently average only 97%. It does not seem to be understood that it is precisely this difference of 2 or 3% that makes the difference between health and disease in a highly polluted water. The water of the Merrimac River, which caused the epidemic at Lawrence, was sedimented before being used, with a removal of bacteria of 95% from plain detention without the use of coagulant. Yet this water carried disease. Now, with sand filters giving only 3 or 4% more efficiency, Lawrence practically has no typhoid. The inference is clear. The St. Louis water is not safe. The figures referred to show this, and the steadily rising rate of typhoid mortality in St. Louis seems to confirm this view.

The treatment here is made with great care by trained men under careful control. Yet the results are imperfect. How much efficiency can reasonably be expected of the "natural" coagulating processes going on in the Monongahela River, with every element of the problem dependent on chance?

At St. Louis iron is added as coagulant in the proportion of from ½ grain to 3 grains per gallon of polluted water; this is equivalent to from 8 to 51 parts per 1,000,000. Monongahela River water, as assayed by the writer, generally contains less than 1 part per 1,000,000 of iron, and days may pass without the iron content rising above 4 parts per 1,000,000. If the process is to be depended on to safeguard consumers of the water from disease like typhoid, the chemical must be present in the stream, not intermittently or irregularly, but every day, and every hour of every day. Even if conditions here were perfect otherwise, the amount of sulphate of iron in the water is not sufficient to coagulate impurities in this stream to any great extent.

In the mind of the average citizen of this section confidence in the safety of the water for drinking arises from the belief that there is much free acid in the stream, destructive to whatever it touches, and hence germicidal to disease organisms. This assertion has been repeated from one to another until it has become an article of faith. As a matter of fact, the bulk of the sulphuric acid entering the water cannot exist long as free acid. It combines instantly with anything available in the water. There are usually over 100 parts per 1,000,000 of lime in [illegible] besides much organic matter. The acid combine, as above described, to form [illegible] lime. There is seldom enough acid to [illegible] all the lime; if there should be, the exce[illegible] would probably be absorbed by the org[illegible] ter; and if there should still be an exce[illegible] as very rarely happens, it would be the [illegible] germicide sought. The question narro[illegible] down to this: How much free acid is [illegible] to kill disease bacteria, and is such a [illegible] present in this river?

The experiments of numerous worke[illegible] shown that sulphuric acid is fatal to [illegible] when the acid is present in sufficient q[illegible] From the mass of data it will be suffi[illegible] quote the results obtained by Rideal.* [illegible] germs were inoculated from pure cultu[illegible] dirty water; this because it is found e[illegible] kill them in clean sterile water than in [illegible] water which occurs in a polluted strea[illegible] organisms were kept at room temperature, with results as follows:

Strength of solution,	Time of exposure.	Result
0.025%	20 hours	killed
0.03%	a. ½ hour	alive
	b. 20 hours	killed
0.035%	½ hour	killed

It is seen that 20 hours' exposure is necessary to kill the bacteria in a solution containing 250 parts per 1,000,000 of sulphuric acid; while half an hour's exposure to a solution containing 350 parts per 1,000,000 is sufficient. If, therefore, such a strength of acid were constantly present in the stream, or a less strength could be counted on for about 20 hours at a time, the faith of these people in the germicidal efficiency of the acid would be well founded. Samples from the river have failed to show any free acid whatever for many days at a time. Evidently, the purification would occur only at irregular intervals. It has repeatedly been shown that germs whose growth has been arrested by exposure to acid, even for a long period, retain their vitality and become vigorous again when favorable conditions once more obtain. If the acid should not be present in proper strength the full time, therefore, the benefit to the water would be very slight.

The hypothesis of the helpfulness of the acid falls to the ground, from the mere fact that there is never by any possibility enough acid in the river. Field assays made during the summer of 1905 failed to show a trace of free acid; analyses made for the Pittsburg Filtration Commission seldom showed over 40 parts per 1,000,000. The highest figures obtained, as far as known, are from analyses made by the chemist of the Carnegie Steel Co., at Homestead; at this point 100 parts per 1,000,000 of acid have been found half a dozen times in the last few years. Upon the proportion of acid present depends the whole virtue of the process. It differs from oxidizing agents like potassium permanganate, in the fact that it is not the quantity of acid that signifies, but the degree of acidity of the whole body of liquid. A given quantity of permanganate would do just as much work in two volumes of water as it would in one, only the action would be slower. The ultimate effect would be about the same. Sulphuric acid, on the contrary, may be strikingly effective in a given strength of solution and be wholly useless if the solution is weakened.

To sum up: The mineral acid, to benefit the water, must act either as coagulant in the form of sulphate or as germicide in the form of acid: for the former there is not enough iron, and for the latter there is not enough acid.

THE WABASH R. R. FREIGHT TERMINAL at Pittsburg, Pa., is a four-story building of steel frame construction, adjacent to the passenger terminal station. The railway is on the second floor level, and the first floor serves as the freight house for receiving and delivering freight. The upper floors serve for storage, etc. There are four elevators of 2 tons capacity, and one of [illegible] tons capacity. The terminal is about 572 × 145 ft., and has cost about $2,000,000.

*Figures kindly furnished by E. C. Murphy, Hydrographer, U. S. Geological Survey, Washington, D. C.

*Am. Public Health Assoc., Vol. XXX.

*"Disinfection and the Preservation of Food." London and New York; 1903.

A CURIOUS ENGINEERING ANALOGY IN CONNECTION WITH THE DESIGN OF THE CLEVELAND BREAKWATER.

An interesting contribution to the history of breakwater design is afforded by some long-lost documents recently discovered by Col. M. B. Adams, Corps of Engineers, U. S. A., now located at Grand Rapids, Mich. In 1877 Colonel Adams was then located at Cleveland, made an official report, estimates and sketches, in which he recommended an all-stone breakwater at Cleveland, O., in place of the old timber crib, stone-filled type, then commonly used. This report was referred to Major McFarland, at Oswego, N. Y., for remark, and appears to have been destroyed in a fire that occurred about that time. On looking over some old papers recently Colonel Adams found the originals on which the lost documents were based.

Through the courtesy of General Mackenzie, Chief of Engineers, we are permitted to publish this old report and the drawings that accompanied it. Our readers will at once perceive the similarity between the design made by Colonel Adams in 1877 and the type of breakwater recently built at Buffalo and at Cleveland with rubble foundation and heart and with large stone covering.

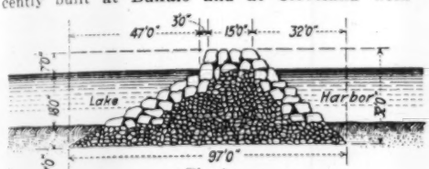


Fig. 1.

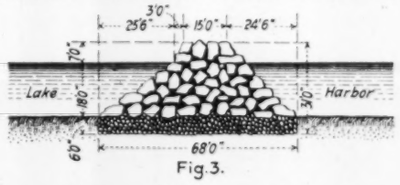


Fig. 3.

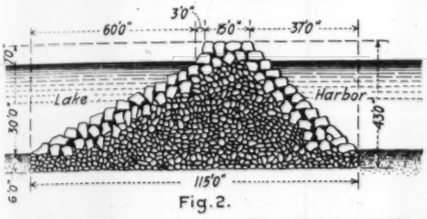


Fig. 2.

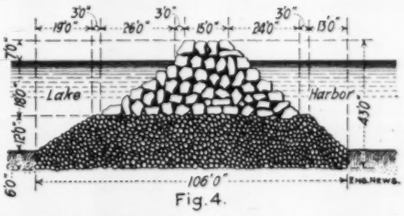


Fig. 4.

FIGS. 1 TO 4. TYPES OF BREAKWATER SUGGESTED FOR HARBOR AT CLEVELAND, O., IN 1877.

It will be seen from the report printed below that nearly 30 years ago the all-stone construction was thought to be cheaper than the timber crib construction.

Cleveland, O., Oct. 11, 1877.

Brig. Gen. A. A. Humphreys,
Chief of Engineers, U. S. A.,
Washington, D. C.

General: During the session of the Board of Engineer Officers, convened to consider the question of a breakwater at Cleveland Harbor, Ohio, in five fathoms of water, and to select the site for the same, the fact of the cheapness of stone in all this vicinity was urged as an inducement towards its adoption in lieu of any other kind of material in the structure.

Since the meeting of the Board, through the ordinary course of operations on the portion of the work now completed, two important considerations have come up, both of which should receive early consideration before the work advances much further, as they relate to its durability and ultimate aid to commerce.

I have the honor therefore to respectfully invite your attention to these questions, as they will be made (as I understand from the Hon. A. Townsend, Congressman-elect from this district) the subject of an interview which he intends asking at the Engineer Department in a few weeks.

I find that large block stone can be had much cheaper than was the case at the time the Board was in session and that the fall in the price of stone of all kinds has been greater than that of timber. Indeed the decrease in the price of stone has been somewhat astonishing or else the price, as given at the time the Board was in session, was unduly great; and consequently the use of timber cribs with stone was adopted rather than stone alone.

Undoubtedly if a stone structure can be built anywhere near as cheaply as the crib one, it would be the more desirable.

I find that by making the outer slope 1 on 1¼ and the inner slope 1 on 1, allowing for 15 ft. thickness on the top and 2 ft. settlement into the bottom, the cost will be about the same whether constructed of timber or made of large blocks of stone, weighing not less than 1½ tons. Such a structure would remain undisturbed under the action of any wave generated for this harbor and if rubble stone was used at 15 ft. below the surface of the water, as foundation, it would not be disturbed. Both of these statements are sustained by actual observations and trials with large stones placed on the end of the completed breakwater where the superstructure has not been carried up and by the fact that drifting sand is seldom carried around the ends of the piers along any portion of this lake when out to the 15-ft. contour.

I have therefore to respectfully submit a design for a stone breakwater, which I have prepared with these facts and positive information as to cost of stone to guide me, and have estimated the comparative cost of a stone structure with one built of stone and timber which are sent you with a drawing of cross-sections of each kind of work in accordance with the verbal sanction of Col. Blunt.

I remain, General,
Very respectfully, Your obedient servant,
M. B. Adams,
Capt. of Engineers, U. S. A.

ESTIMATE.

(Report of Capt. M. B. Adams, on breakwaters, Oct. 11, 1877.)

[Note: It is to be observed that the retained papers are not exactly in accord; the estimates, report and sketches not exactly agreeing. The estimates provide for a 25-ft. width in the structures at water level; the report only mentions slopes of 1 on 1½ outside and 1 on 1 inside, with a crown 15 ft. wide. This would give a thickness of 32½ ft. at water level. One sketch gives a cross-section with outer slope of 1 on 2 and this agrees more nearly with the statement in the report, that "the cost will be about the same whether constructed of timber or made of large block stone," than either of the others, as follows:]

For a crib 50 ft. long and superstructure in 18 ft. of water, the following is required at ruling prices:

Timber, 57,488 ft. B. M., at $20 per M		$1,149.76
Rubble stone for foundation, 7 ft. × 50 ft. × 50 ft. =	17,500 cu. ft.	
Rubble stone for filling, 20 ft. x 25 ft. × 50 ft. =	25,000 cu. ft.	
	42,500 cu. ft.	
or 332 cords at $4 per cord		1,328.00
Iron, bolts, spikes, etc		75.00
or $50.10 per lin. ft.		$2,552.76

For stone structure in 18 ft. of water (Fig. 1):

Total area of cross-section, 15 ft. × 32 ft. + 32 ft. × 16 ft. + 25 ft. × 25 ft.	1,517 sq. ft.
Total area of rubble stone in cross-section, 7 ft. × 97 ft. + 30 ft. × 18 ft.	1,219 sq. ft.
Total area of large stone	298 sq. ft.
For each lineal foot of breakwater there will be required 1,219 cu. ft. = 9.1 cords, at $4 per cord	$36.40
And of large stone there will be required (allowing ⅖ for interstices) ⅗ × 298 = 181 cu. ft. solid of large stone (140 lbs. per cu. ft.) = 25,340 lbs. = 12.7 tons at $1 per ton	12.70
Total cost per lin ft.	$49.10

(A note appears on this sheet that a Mr. Carrier will contract with good security to furnish 42,000 tons of large stone per year at $1.25 per ton.)

For stone structure in 30 ft. of water (Fig. 2):

An estimate of cost for the crib structure being built in 1877 at contract prices was made and in 18 ft. of water it was shown to cost $77.40 per lin. ft; then the following:

Cross-section of stone structure in 18 ft. of water (Fig. 3), stone foundation, 68 ft. × 6 ft. =	408 sq. ft.
Stone substructure and superstructure $\frac{25 \text{ ft.} \times 68 \text{ ft.}}{2} \times 18 \text{ ft.} + \frac{15 \text{ ft.} + 25 \text{ ft.}}{2} \times 7 \text{ ft.} =$	977 sq. ft.
The former by the cord, for each lineal foot of breakwater will cost, 3.1 cords, at $4 per cord	$12.40
The latter, by the ton, allowing ⅖ for interstices, will cost ⅗ × $\frac{977 \times 140 \text{ lbs.}}{2{,}000 \text{ lbs.}}$ × $1.25 per ton	50.16
Total	$62.56

The crib structure then being built at contract prices, if in 30 ft. of water, was estimated to cost $130.42 per lin. ft.

Cross-section of stone structure in 30 ft of water (Fig. 4): Stone foundation 106 ft. × 6 ft. + $\frac{106 \text{ ft.} + 74 \text{ ft.}}{2}$ x 12 ft. = 1,716 sq. ft. of rubble stone in cross-section, or 13.5 cords per lin. ft., at $4 per cord	$54.00
Large stone, in substructure and superstructure, the same as before ⅗ × $\frac{977 \times 140 \text{ lbs.}}{2{,}000 \text{ lbs.}}$ × $1.25	50.16
Total cost per lin. ft.	$104.16

[Note: The stone arriving at the work (crib filling and riprap) was weighed by boat displacement and was measured in cords; and as the factors ⅗ solid, ⅖ interstices were assumed as correct the weight of the stone, 140 lbs. per cu. ft., necessarily resulted. It would have been nearer the truth to have taken the factors at ½ and the stone at 168 lbs. per cu. ft., though the resulting weight would have been the same.]

COAL AND COKE EXPORTS of the United States in 1905 aggregated about 9,000,000 tons (2,240 lbs.), valued at about $31,000,000. Anthracite makes up $11,000,000 of this, and coke $2,000,000. The larger part of the coal went to British North America, including about two-thirds the bituminous exports and nearly all the anthracite. Mexico and the West Indies took most of the remaining bituminous. The exports of coal from this country to Canada have about doubled in the ten years 1895 to 1905. The coal exports of Great Britain are about five times those of the United States, while Germany exports about twice as much coal as the United States. The figures above given do not include coal supplied to vessels engaged in foreign trade; in the case of the United States this amounted to 5,000,000 tons in 1905. While third in the list of coal exporting countries, the United States leads in production. The latest available year, 1904, showed productions as follows: United States, 314,563,000 tons; United Kingdom, 232,428,000 tons; Germany, 118,907,000 tons; France, 33,303,000 tons; Belgium, 23,135,000 tons; Japan, 9,702,000 tons.

STREET RAILWAY TRACK CONSTRUCTION on the Madison & Interurban Ry. includes concrete foundation in the business streets and stone ballast foundation in the residence streets. In the former case, the width of concrete is 7 ft., with a depth of 11 ins. for a width of 20 ins. at each side (under the rails) and 6 ins. at the middle. The 6-in. 72-lb. tee rails are secured by clamps on anchor bolts, and are connected by transverse tie rods. Granite blocks are laid against each side of each rail, and the rest of the street is paved with asphalt. The inside blocks are chipped to form the flangeways. In the residence streets, and at all special work, the rails are spiked to timber ties, and a bed of concrete is filled between and over the ties to support the granite blocks and the paving. The rail joints are spliced during construction, and afterwards cast welded on the Falk system.

THE SALARIES OF THE ENGINEERS of the New York Rapid Transit Commission are published in the "City Record" of Jan. 30. Some of the important items are as follows:

MAIN OFFICE.

1 Chief Engineer	$15,000.00
1 Deputy Chief Engineer	7,000.00
1 General Inspector of Designs	4,000.00
4 Assistant Engineers	10,000.00
17 Draftsmen	24,740.00
1 Private Secretary to Chief Engineer	2,100.00

Division Engineers receive a salary of $4,000 per annum and the Assistant Engineers under them are paid on the average considerably less than the Assistant Engineers in the Main Office. The appropriation for the 28 Assistant Engineers' salaries on the Third and Fourth Divisions, for example, is $45,000. In the Inspection of Material Department the salaries are as follows:

1 General Inspector of Material	$3,600.00
10 Inspectors of Steel	14,080.00
1 Steel Chemist	1,680.00
4 Cement Testers	4,800.00

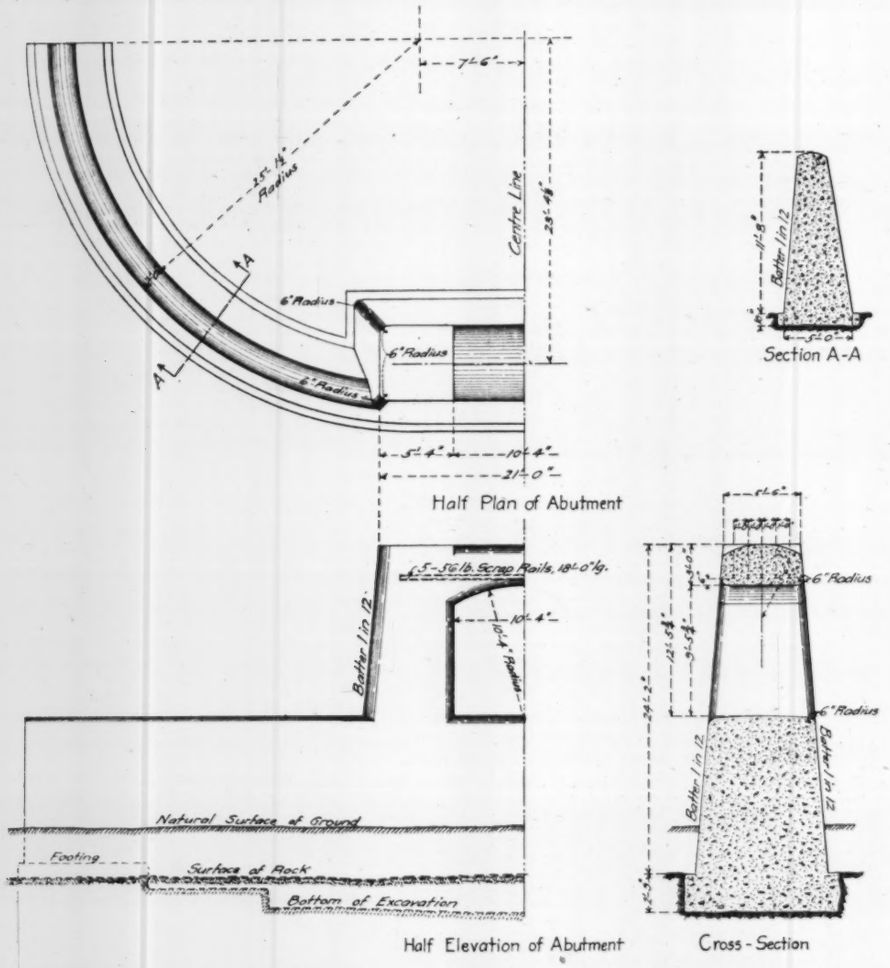
A NEW PROCESS FOR CASE-HARDENING IRON has been developed by two Prussian inventors, according to the "Iron & Coal Trades Review." This process advocates adding to the iron a small percentage of phosphorus combined with a large amount of carbon. The iron is heated in a tempering powder of bone dust, to which are added 300 grains of yellow prussiate of potash, 250 grains of cyanide of potassium, and 400 grains of phosphorus. The receptacle in which the iron and these ingredients are placed is closed and the cracks filled with clay, and then raised to a clear red or white heat. The material treated is then taken out and plunged, while still hot, into a warm bath. It is claimed that a piece of iron weighing 400 lbs. can be hardened to a depth of .04 ins., and that the iron so hardened can neither be cut nor chipped by the best steel used, although it can be readily welded.

AN ECONOMICAL CONCRETE ABUTMENT.

By C. R. Young.*

A concrete abutment of economical design was recently constructed at the Etobicoke River, about seven miles west of Toronto, on the Mimico Division of the Toronto & York Radial Ry. The railway, which is an electric one, carrying a heavy suburban traffic, crosses the river valley by 600 ft. of wooden trestle, a 140-ft. through truss steel span and 800 ft. of fill, averaging 18 ft. deep, commencing immediately to the west of the 140-ft. span, thus necessitating an abutment at this point.

Saving in concrete was effected in two ways. First, the fill was stopped 30 ft. from the center of the abutment and allowed to slope down all around on a slope of 1½ to 1 to the circular wing walls, the tops of which are slightly above high water mark. A short wooden trestle, put in before filling commenced, carries the traffic from the bridge on to the fill. Second, a saving of some 24 cu. yds. of concrete was effected by leaving an arched opening in the center of the abutment where the material is ineffective.



CONCRETE ABUTMENT, TORONTO & YORK RADIAL RAILWAY, NEAR TORONTO, ONT.

Details of the structure are shown by the accompanying illustration. The arch between the truss-seats was reinforced by five 56-lb. scrap rails, placed 1 ft. apart, as shown. This reinforcement was for the purpose of tying the "towers" rigidly together and to ensure the arch carrying without danger the ends of the stringers from the temporary trestle across the river, which were supported on a cradle resting on the arch.

The design was that of Mr. James McDougall, Assoc. M. Inst. C. E., Chief Engineer of the railway. The concrete work was done by Mr. O. L. Hicks, Humber Bay, Ont.

*Assistant Engineer, Toronto & York Radial Railway, Toronto, Ont.

SINKING A MINE SHAFT THROUGH WATER-BEARING MATERIAL BY THE AID OF STEEL SHEET PILING.

In the article on steel sheet piling in our issue of Nov. 23, 1905, mention was made of the use of this material in the successful sinking of a mine shaft through soft material after two unsuccessful attempts had been made with shafts sunk in the ordinary way. The shaft in question was the Auburn shaft of the Robert Gage Coal Co., Bay City, Mich., and for the following particulars of the work we are indebted to Mr. Charles Coryell, Vice-President and General Manager of that company.

The sinking of the coal shaft near Auburn, Mich., was commenced on March 10, 1904, and the shaft was made 9 × 16 ft. in the clear. After going through about 50 ft. of clay, a bed of sand and gravel was encountered, producing a very large amount of water. Work was continued for about four months, using a steel shoe which was forced through the sand by 40 jack screws, but when this had been sunk about 30 ft. into the bed of sand (and was still about 15 ft. from the underlying rock) the surface caved in around the shaft, owing to the pumps having removed large quantities of sand with the water. As a result of this caving the timbers were broken and the shaft was thrown out of line, so that the work was abandoned. Two other attempts were made in the same neighborhood, but these resulted in similar failures; and Mr. Coryell estimates that about $75,000 were lost in these three unsuccessful attempts to sink the shaft through the bed of water-bearing sand and gravel. There were sometimes as many as seven 6-in. streams of water coming from the sand, and it was found impossible to prevent the sand from coming in with the water and causing large voids behind the timbering.

The use of steel sheet piling [illegible] gested, the special feature of the [illegible] the piles would be driven through [illegible] material to solid bottom and a co[illegible] formed before any excavation of [illegible] was begun. It was decided, ther[illegible] another attempt and to use the [illegible] locking steel piling. The fourth s[illegible] started, being sunk in the usual wa[illegible] 50 ft. of surface clay and about [illegible] sand bed. At this point the use of [illegible] was commenced, and the piles we[illegible] depth of 20 ft. Each 20-ft. pile wa[illegible] two 5-ft. pieces and one 10-ft. pi[illegible] lengths being used in order to get th[illegible] machine under the braces in the h[illegible] the shaft. The 5-ft. and 10-ft. se[illegible] jacent piles broke joint with one an[illegible] joints in each pile were spliced with [illegible] on, a band of copper being fitted [illegible] ends of the sections. The splicing to[illegible] time and did not retard the driving [illegible] Some boulders were encountered, but [illegible] broken or driven out of the way with[illegible] culty. At the bottom the piles penetrated 18 or 20 ins. into the slate rock, making a [illegible] When all the piles had been driven, so as to form a complete caisson, the excavation of the sand was commenced, the shaft being timbered as the work progressed. The shaft was 7 × 14 ft. clear inside the timbering, and after reaching the rock it was sunk through that in the usual way.

The method employed for driving the piles at the bottom of the excavated shaft is of special interest. At the surface and near the top of the shaft was a Star drilling machine, handling a 1,600-lb. hammer by means of a jerk-line and giving it a drop of about 3 ft. The hammer was guided by a system of sheaves and guided directly over the piling by a large piece of pipe made of heavy sheet steel. The use of a water jet to facilitate the work was tried at first, but this caused the sand to boil up in the shaft, and was abandoned. There was no trouble in driving the piles, but considerable time was consumed in changing the tackle to drive each piece.

A DUPLEX COMPOUND TANK LOCOMOTIVE for pusher service on heavy grades has been built for the Belgian State Railways by the Societe Anonyme de Saint Leonard, of Liege, Belgium. It is a four-cylinder engine on the Mallet duplex system, in which the rear group of wheels is carried by the main frames, while the front group is carried by a swiveling truck frame under the boiler. This truck is pivoted at its rear end. The high-pressure cylinders are in front of the rear (fixed) group of wheels, and are inclined 3.85%. The low-pressure cylinders are on the front of the truck frames and have an inclination of 7.1%. The engine is of the 0-6-6-0 class, and has water tanks on the main frames (alongside the firebox) and also on the truck frames; these latter are added to increase the adhesion of the driving truck. As the engine is designed to burn fire slack coal and waste it has a firebox of enormous area but very small depth. The general practice in Belgium, however, is to use briquettes made of this fine coal, so that the shallow firebox is gradually disappearing. There are two fire doors, and two firemen are required to maintain the thin and even fire necessary with this grade of fuel. The engine was built specially to assist trains up the 3% grade from Liege to Ans, where heretofore two pusher engines of the 0-8-0 class have been used for each train. The engine is in some respects comparable with the French duplex compound tank locomotive of the Fairlie system, illustrated in our issue of Dec. 21, 1905. The dimensions of the Belgian engine are as follows:

Class	Duplex; 0-6-6-0
Driving wheels (12)	4.26 ft.
Wheelbase, each group	9.84 ft.
Wheelbase, total	31.47 ft.
Length over all	48.87 ft.
Weight (empty, 201,880 lbs.)	241,560 lbs.
Cylinders, h. p. (2)	19⅝ × 25½ ins.
Cylinders l. p. (2)	31½ × 25½ ins.
Valve gear	Walschaert, with piston valves.
Boiler, diameter	5.04 ft.
Dome, diameter, 27.2 ins.; height	3.29 ft.
Smokebox, length	6.50 ft.
Working pressure	200 lbs.
Firebox (Belpaire); length, 9.71 ft; width	8.73 ft.
Firebox, depth, at tube plate, 4.30 ft.; at back	2.65 ft.
Tubes (brass, ribbed); No.	164
Tubes, diameter, outside, 2.75 ins.; length	13.26 ft.
Heating surface, tubes	708 sq. ft.
Heating surface, firebox	161 sq. ft.
Heating surface, total	869 sq. ft.
Grate area	14.5 sq. ft.
Height, rail to top of smokestack	9.87 ft.
Width, extreme	26 ins.
Smokestack, diameter, at base, 36 ins.; at top	26 ins.
Coal in bunker	6,612 lbs.
Water in tanks	19,836 lbs.
Tractive force, theoretical	48,580 lbs.
Tractive force, effective	41,360 lbs.

ENGINEERING NEWS

Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
SAN FRANCISCO: Rialto Building
BOSTON: 170 Summer Street
ATLANTA: Austell Building
RUDOLF MOSSE, BERLIN AND HAMBURG, GERMANY

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Other Countries, Thin Paper Edition (Construction News Supplement Omitted), $5.00. 21 Shillings, 25 Francs or 21 Marks.
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Entered at the New York Post-Office as Second-Class Matter.

Water meters are much to the front in both New York and Philadelphia just now. As usual, the opponents of water waste prevention, particularly in New York, are crying out that the advocacy of meters is designed solely to benefit some manufacturer of those devices. It never occurs to such people that the failure to stop water waste makes necessary more and larger contracts for other things than meters, and gives far greater opportunity for graft than would be possible if every consumer in a city were metered. No better illustration of this truth can be given than Philadelphia. The Hering-Wilson-Gray Commission of 1899 advocated the restriction of water waste, and Mr. John C. Trautwine, Jr., as Chief of the Philadelphia Bureau of Water, was persistent in his arguments for waste prevention as a preliminary to the construction of filters. Mr. Trautwine had his labor for his pains, was virtually ordered by his political superiors to shut his mouth, and finally resigned his position rather than be a party to the construction of filters double the necessary size in order that the people of Philadelphia might let half or more of the water pumped and filtered at great cost run back to the river through the sewers. Then followed those huge filtration and pipe contracts, with a time-element never designed to be enforced, but subtly intended to drive away all bidders outside the ring. Could any favoritism to meter manufacturers equal that shown to filter and pipe contractors at Philadelphia prior to the advent of the reform administration? We have no hesitation in saying that the additional expenditure for pumps, filters and pipes at Philadelphia, to provide for utterly inexcusable waste, would have more than paid for a meter on the service pipe of every consumer. Fortunately there is still an opportunity to retrieve some of the useless expenditure planned but not yet contracted for at Philadelphia, provided waste prevention measures are initiated immediately. Contracts are to be let at once for pumps to supply the Torresdale filters. If reasonable waste prevention measures were adopted these pumps might be of only 120,000,000 gallons daily capacity, instead of the 200,000,000 gallons otherwise necessary. It is on such extravagant lines as this that the whole Philadelphia filtration system has been conceived and executed. The popular opposition against water meters, and the results flowing therefrom, has been made the excuse of building works 50 to 100% larger than were actually needed. Waste prevention was to be postponed until the filtration plant and accessories were completed, after which meters were to be installed sufficiently fast to curtail the per capita rate of consumption to correspond with the growth in population: thus the filters would supply the needs of the city for some fifty years to come. The beauty of this plan, for local politicians and political contractors, was that it shuffled off onto future city administrations the unpleasant task of waste prevention and concentrated in one brief period contract work that would normally be distributed over many years.

The present situation in New York is far different in many of its aspects from that at Philadelphia, but exactly the same in some. New York must have a large addition to its water supply, and that as soon as possible. Although the per capita water waste in New York is far less than in Philadelphia, yet it is so large and its curtailment so simple that a crusade against it should be made at once. Such a crusade, contrary to the opinions of some well-meaning persons, would have little effect upon the size and character of the new works to be constructed by the Water Supply Commission, for reasons that need not be stated here. But prompt and effective waste prevention measures in New York would be in the nature of insurance against the water famine that will come with the year of very low rainfall that may be expected soon, and that is sure to come before the Catskill supply can be made available. Waste prevention would greatly reduce the cost of the proposed filter plant for the Croton supply and would improve the water pressure throughout a large part of the city. Of less immediate value, but of incalculable future benefit, waste prevention intelligently and vigorously pursued at present would so reduce the waste as to simplify the great water problem of a very few decades hence. Just as the new Croton supply became insufficient long before the New Croton Dam was completed, so may the $161,000,000 Catskill supply now projected. That supply, relatively sooner than the Croton, will have to be filtered. Other municipalities within 150 miles of New York are growing rapidly. Their water needs will soon overlap those of New York, even more than at present. The time will soon come, if it has not already, when it will be difficult to provide sufficient water for actual use; impossible to secure pure water to waste. Besides all these reasons, presented in the barest outline, for the more extended use of water meters there are two others, both of great importance: (1) Meters afford the only equitable means of distributing the cost of water between consumers; and (2) no city can afford to build, maintain and operate works to provide water to waste when there are so many sanitary and other public improvements crying out for appropriations.

The crusade against tuberculosis among government employees at Washington, D. C., announced in an order issued by President Roosevelt on March 8, may well serve as an example to state and municipal governments. The order provides for the posting of rules in every Federal building; the ascertainment, by personal examination where necessary, of all tuberculous persons, the issuance to such persons of rules to guard against the disease, and the permissive discharge of any one who fails to observe the rules; and finally sanitary boards to examine all Federal buildings and to report needed changes in the buildings, both such as can be readily made and such as require structural alterations. It is particularly fitting that the national government should enter upon this work, and it is desirable that its example should be known and followed not only by the several states and municipalities of the country, as we have already suggested, but also by the managers of public and private institutions, and the proprietors of industrial and commercial establishments. Tuberculosis is one of the most readily preventable of all the communicable diseases, but through centuries of ignorance of the means of its dissemination it is also one of the most widespread of all diseases. The foci of infection are numerous and most of the victims succumb slowly; therefore, when neglecting simple precautions, they sow the germs of tuberculosis for months and years. Were not most individuals strongly resistant to the invasion of these germs the human race would have been annihilated long before this. Such measures as have been inaugurated at Washington, combined with the educative and preventive work already being done elsewhere, will greatly hasten the already falling death rate from tuberculosis.

An item of news which must interest particularly engineers whose memories go back to the days of smaller things in engineering is received from Cleveland, O. We print it as follows:

> An engineering association, holding monthly meetings, has been formed by the engineers of the home office of The Roberts & Abbott Co., of Cleveland, O. Each engineer reports as to any special data published during the preceding month in two technical papers, and also any matter which he considers of special interest. Mr. Roberts and Mr. Abbott report on any matter of special interest which has come to their notice. At the last meeting, recent tests and results obtained with reinforced concrete were discussed, and also the different methods of starting rotary convertors. The greater number of the engineers are in the field, but as the majority of the chief engineers are generally in the home office, the meetings have already been found interesting and valuable.

It is not a very long time ago that it was difficult and frequently impossible, even in cities of large size, to find a sufficiently large number of engineers to form an association. Now we have a single engineering firm devoted to a single branch of engineering work (electric railway and power station engineering) employing a sufficiently large staff to have a working engineering society among the men at its headquarter office alone.

The item also suggests the thought that an increasingly large proportion of engineering work is coming into the hands of the large organizations, which can bring together experts experienced in a wide range of work. It is becoming increasingly difficult for the independent engineer, working alone or with a small staff, to compete with the large, well managed organizations in the conduct of engineering work.

SHALL THE PANAMA CANAL BE BUILT BY CONTRACT?

In a very short time the United States must face the question whether it will carry on the work at Panama by its own forces or whether it will undertake to let the work to contractors. A mistaken idea became current some time ago that the Government's purchase of steam shovels, rock drills, rolling stock, etc., needed for the work at Panama, indicated an intention to carry out the whole work by day labor. As a matter of fact no such conclusion was warranted. The machinery must be purchased and set up, whoever does the work, and if its purchase had been postponed until contracts were let, it would have involved a further delay of a year or two after contracts were let before actual work could begin. There is no doubt whatever that Mr. Wallace and Mr. Stevens were as competent to decide what machinery will best do the work at Panama as any contractor, and it was entirely proper, therefore, to purchase the equipment for the Panama work and bring it onto the ground, no matter what decision might be reached later respecting the letting of contracts.

It may be added further that the actual experience which is being gained in carrying on the work will be of great advantage to the Government even if the work is later put under contract, as a clear idea can then be formed as to the cost of the work, and it can be known whether the bids of contractors are reasonable or not.

The question of contracts or day's work at Panama is, therefore, still an open one, we feel warranted in saying, in the mind of the Executive, and of those members of Congress who are giving close study to the canal problems. Undoubtedly the Canal Commission and their engineers will be glad to let contracts for the work if the work can be successfully accomplished in that way at a reasonable figure; but the unusual and unprecedented conditions at Panama have first to be carefully considered.

We abstracted in our issue of March 1 Mr. John

F. Wallace's testimony before the Senate Committee relative to contract work at Panama. In the "Engineering Magazine" for March, Mr. Wallace has expressed his opinions on this subject still more explicitly, and we quote as follows:

Various suggestions have been made as to building the canal by contract work, particularly as to dividing the work up into small sections and letting it out to a multitude of contractors. Such a plan would raise up a multitude of more or less antagonistic, or at least jealous, interests, leading to endless confusion and little, if any, gain in efficiency over the present methods. The situation at Panama is peculiar. If it were simply a canal to be constructed through a comparatively flat country where the excavated material might be thrown on the banks, the small-contract system could be adopted; but the case is totally different. The crux of the work is the Culebra cut, which, in the case of the high-level canal will be from five to eight miles long, and this work would necessarily have to be under one contractor. The Panama Railroad and the machine shops would have to be subject to that contractor's control, as the material in some cases will require transportation the entire distance across the Isthmus. The question of control of the commissary, the rate of wages paid by the sub-contractors and a host of other details, make it necessary, to my mind, for a single contracting organization to control the entire work.

The fewer the specifications, the more simply they can be drawn, and the larger the amount of authority which can be left to the contractor and his engineers in designing and executing the details of the work, the less will be the cost and the shorter the time for completion. While the tendency will be to make the specifications most elaborate and to place the work, even to its details, under the close supervision of men employed directly by the Government, the best results will be obtained if the authorities in control of the undertaking can guard against the bad effects of this tendency.

The ultimate conclusion which I arrived at—and this was not the result of merely professional ideas, but of careful consideration of all the conditions at the close of my year's experience—is that under all the conditions surrounding the undertaking, only two courses remain to be pursued. Either (1) the work should be put into the hands of one strong man, with practically unlimited authority, combining the technical and scientific training of the engineer with the administrative and executive ability of a man of force; with this should be coupled the separation of all matters connected with this work from the control of the ordinary Government departments at Washington—but under such supervision only as to insure the Government that his administration is efficient; or (2) the same result should be accomplished through the letting of the work to a contracting firm, large enough to control under one management the entire constructive work on the Isthmus, under broad and general specifications and under such general supervision as may appear to Congress to be proper. The first step of any contracting firm would then be to place its affairs in the hands of a strong single executive, supported by such advisory technical knowledge as might be deemed necessary. The precedent for this method, and a working application of this principle, is the special agreement which was made for the construction for the improvements at the mouth of the Mississippi under Capt. Eads. It was a contract which bound the contractor to nothing but certain results for a certain sum, and no more satisfactory compact for public work was ever made by the United States.

That there are very great practical difficulties in the way of dividing up the Panama work in sub-contracts has already been pointed out in this journal; and it is evident that Mr. Wallace from his experience and study on the Isthmus fully appreciates them. Of course these difficulties may be to some extent overcome, and it is conceivable that separate contracts could be let for such works as the harbor improvements at either end, or the lock gates or the lock operating machinery, or even the building of the Gatun dam. But the practical difficulties in the way of dividing up the Culebra cut or the Gatun locks or the Gatun dam among several contractors appear to be insurmountable.

Let us now turn to Mr. Wallace's proposal to let the work outright, in one huge total to a single great contracting firm. This is not the first time, nor will it be the last, doubtless, that such a proposal will be made and it deserves serious attention, the more so as the same question is coming up elsewhere in relation to other great engineering works.

Is it possible to put under contract a great complicated piece of engineering work, involving an expenditure, let us say of twenty millions of dollars or more and secure real competitive bidding, so that the work will finally be accomplished at no more than actual cost plus a reasonable and liberal profit to the contractor?

Suppose the United States Government were to call for bids for building the Panama Canal, the whole work to be let in one contract. How many bona fide bidders would come forward? Where is the contractor or contracting organization large enough to make a real bid for the work accompanied by *sufficient financial guarantee* that the work will be actually completed in the time and manner specified and for the total sum bid?

To ask such a question is to answer it. There are no actual contractors ready to bid on such a vast work, or even on works of much lesser magnitude. If any bids for such work were received, they would be purely speculative bids, unbacked by substantial guarantees, or else bids from financial syndicates. It is possible that some great banking house might form a syndicate to conduct the work, and financially guarantee it; but with the "community of interest" prevalent in financial circles, it would be beyond expectation that more that one such syndicate would be organized. No possibility appears, therefore, that a contract for the Panama Canal as a whole, or even for the Culebra cut, could be let under real competition.

If anyone doubts the truth of this assertion, we invite them to point out a single instance where any such vast contract has been let, and where bona fide competitive bids have been secured. Of course large contracts have been repeatedly let, involving large sums; but they have been let under conditions very different from those here set forth.

The experiment was tried in New York City when the Rapid Transit enterprise was undertaken. Those who framed the Rapid Transit law had a childlike faith in the principle of free competition and a profound distrust of the city's competence to do anything for itself. This led to the incorporation in the law of the requirement that the city must let one lump contract for the construction, equipment and operation of the whole road for a term of years, a contract involving an expenditure of 35 to 50 million dollars, and continuing for a quarter of a century. It was, as everybody now knows, a concession of enormous value that the city offered, and it might have been reasonably expected that financiers from all over the world would have submitted bids.

When the day came, however, and the bids were opened, it was found that just two bids had been made and these not by financiers but by working contractors who had not yet made good the financial guarantees required to validate their offers. One of these bids was afterward taken up by a financial syndicate; but in the light of present knowledge, it is clear that the attempt of New York City to obtain competitive bidding for its enormously valuable Rapid Transit contract was a total failure.

This notable experience in New York well illustrates the impossibility of obtaining real competition in letting contracts of huge size; but it may be worth while to see the reason *why* competition on such contracts is out of the question and why such huge lump sum contracts can only be let at extravagant prices. To see this we have only to consider how large contractors or great financiers view the matter.

Every business firm, whether engaged in banking or in contracting, is in business to make profits. It is willing to take risks in its business, *so long as those risks are not out of proportion to its total capital*, and so long as the possible profit is proportioned to the risk; but it will not assume risks above this amount. A great contracting organization may have twenty to forty million dollars of work on its hands, spread over a dozen or a hundred pieces of work, and if there is risk and loss on one it will be made up by profit on others. Such a concern could not safely undertake a single contract involving twenty to forty million dollars, and with the same amount of risk that its other contracts contain; for loss on such a contract would mean its entire bankruptcy and would wipe it out of existence.

There are just two kinds of offers which the Government might receive for huge contracts at Panama. It might possibly receive [illegible] offer backed by sufficient capital to make go[illegible] very guarantee in the contract; but any such [illegible] will of necessity name a price involving larg[illegible] its, larger by far than the Government could [illegible]rly pay without national scandal resulting.

The other kind of offers which the Go[illegible]ent may receive will on their face appear to [illegible]ery-thing that could be desired; they will [illegible]e a fairly moderate price for the work, and [illegible] to assume any and all risks in its performa[illegible] *but they will be unaccompanied by sufficient* [illegible]*cial guarantees to insure the actual performan*[illegible] *the contract.* The point we wish to emphasize [illegible] that any and every such contract is actually [illegible]me of "heads, I win; tails, you lose" for t[illegible]on-tractor. If the risk proves greater than h[illegible] been supposed and losses appear instead of prof[illegible] the contractor becomes bankrupt, his sureti[illegible] find ways to escape their obligations and the Gov-ernment has to relet the work to some o[illegible] else, usually at a higher figure on account of th[illegible] risks disclosed. If on the other hand the risk[illegible] prove less than estimated and the work easi[illegible] the contractors profits grow apace, and he r[illegible]ives much more than a reasonable profit on his work. It is this latter possibility that may very likely bring forward speculative bids for the Panama work. There are plenty of people who will risk a half a million or a million dollars for equal chances of making five or ten millions or even more. These speculative bidders may very likely come forward with strong political backing; but we believe that on no account should the work at Panama be farmed out on such a basis.

In the quotation above from Mr. Wallace, the contract with Capt. Eads for the South Pass jetties is cited as a good model for the Government to follow in letting the Panama work. It is surprising that such an example should be cited, for the Eads contract has gone into engineering history, we believe, as an illustrious example of the wrong way to carry out Government works. The South Pass channel cost the Government, it is generally agreed, a far larger amount than it would have cost had the Government undertaken the jetty construction itself, in the same manner that it has all its other works of harbor improvement. There may be some reason, where it is necessary for work of a doubtful or experimental nature to be undertaken, to let a contract and call only for the accomplishment of certain results; but with the advancement of engineering science and practice the occasion for such contracts very rarely occurs.

Engineering News has long maintained that the true principle in letting contract work is to relieve the contractor of all possible risk. The burden should fall and almost inevitably will fall, despite all artifices to the contrary, on the party for whom the work is done. If contracts are to be let at Panama they should be let in full recognition of this principle.

We have already alluded to the other general principle, governing contract work; that contracts must not exceed a certain size, not too large for a number of contractors to bid upon, if real competition is to be obtained.

No better illustration of this principle could be given than the contrast between the subway construction in Boston and in New York. The Boston subway was cut up into small contracts, which were let under close competition, and the city secured the completed work at a very moderate advance over its actual cost. New York called for bids for its subway work as a whole, complicating it with operating conditions, the whole making a contract of such stupendous size that only two bids were received, and as noted above neither of these bids when made had actual capital behind it. The result was a contract, let practically without competition, which has netted its possessor an enormous amount. The actual work, of construction, it should be noted, was sublet by the contractor, who divided the work into sections, just as the city itself might have done and doubtless would have done had it not been tied hand and foot by the terms of the Rapid Transit law.

In considering the question of contract work vs. days work at Panama, it must not be forgotten

that the Government has already done a large part of the things which ordinarily fall upon the contractor, and that the Government must continue to do these things through all the years to come while the canal is completed. The Government does the sanitation of the canal zone, the policing, the hospitals, the commissary, the transportation lines from the Atlantic seaboard to points where machinery and materials will be supplied, the real estate, the repair shops and machinery, the working plant and equipment already on the ground.

The Government has done all these things with its own organization and its own hired labor; and there appears to be pretty general agreement among all those qualified to speak regarding these matters that the work has been well done. Having progressed so far, having done all the things in connection with the work that ordinarily fall upon the contractor, it is not apparent why the Government should not do the rest, and pay directly the wages to the men who will operate the steam shovels and the drills instead of paying a contractor to pay them.

It must be remembered that the Government must have its own engineers in charge from start to finish. All work must be done in accordance with their directions and to their detailed plans. It will not be an enormously greater task for these engineers and inspectors to supervise the actual work of men employed directly by the Government than to supervise the same men working directly for a contractor.

In conclusion, our opinion is that the canal work is now in efficient hands. Mr. Stevens and the members of the Commission are men of very large practical experience in works of engineering construction. They should be left, we believe, to follow the same intelligent judgment that they would exercise if working for a railway company. If contracts can be let to advantage, they will certainly be glad to unload part of their responsibilities in that way; and if they find that contract work is precluded by existing conditions, they should be as free to continue the day's work system as they would be if the work were being done by private capital in the United States.

LETTERS TO THE EDITOR.

The Caisson System of Submarine Tunnel Construction in 1901.

Sir: Referring to the article on page 177, of your issue for Feb. 15, 1906, entitled "The Remarkable Tunnel Crossing of the Seine by Line 4, Metropolitan Railway of Paris," I would like to call your attention to the inclosed blue print, dated Jan. 24, 1901, over five years ago. At that time the Pennsylvania R. R. Co. was considering plans for crossing the Hudson River. This blue print and this proposed method of sinking the cribs was submitted to Mr. Samuel Rea, Vice-President of the Pennsylvania R. R. My plan was to excavate a ditch, with a clam shell dredge, to the necessary depth, back-fill the same with rubble stone for a suitable depth, as now proposed for the Detroit River tunnel by Messrs. W. J. Wilgus and H. A. Carson, of the Advisory Board of Engineers, float the cribs in place and sink them. Of course the details were not all worked out, but the main idea is there.

Yours truly,

Emile Low, M. Am. Soc. C. E.

153 Lancaster Ave., Buffalo, N. Y., March 3, 1906.

How to Remove an Instrument Stuck on Its Tripod.

Sir: It frequently happens that an instrument will get stuck so fast to the head of the tripod that it cannot be unscrewed. I have known instruments to be left "set-up" for days or even weeks at a time, and I have seen them removed with a cold chisel or an ax when it was absolutely necessary to put them away.

Some time ago I discovered a trick which may be of use to some of your readers, although others may know of a better scheme.

Take a firm grip with your hands and unscrew as hard as you can, and at the same time have your rodman grab two legs of the tripod near the head and give a quick twist in the opposite direction. I have never known this method to fail to start the stuck thread.

Yours truly, S. D. C.

Assamoosick, Va., March 8, 1906.

The Cross-Section of a Sea-Level Canal in the Culebra Cut: Correction.

Sir: In Engineering News of March 1 you show, p. 242, two cross-sections of the deepest part of the Culebra cut on the Panama Canal, one for the lock canal and one for the sea level.

I wish to call your attention to an error in the sea-level section, said error being the point at which the 1 on 3 slope commences and the stepped slope ends.

This 1 on 3 slope is the slope in earth, and in all cases for both the lock and sea-level plans should commence at the elevation of the top of the rock.

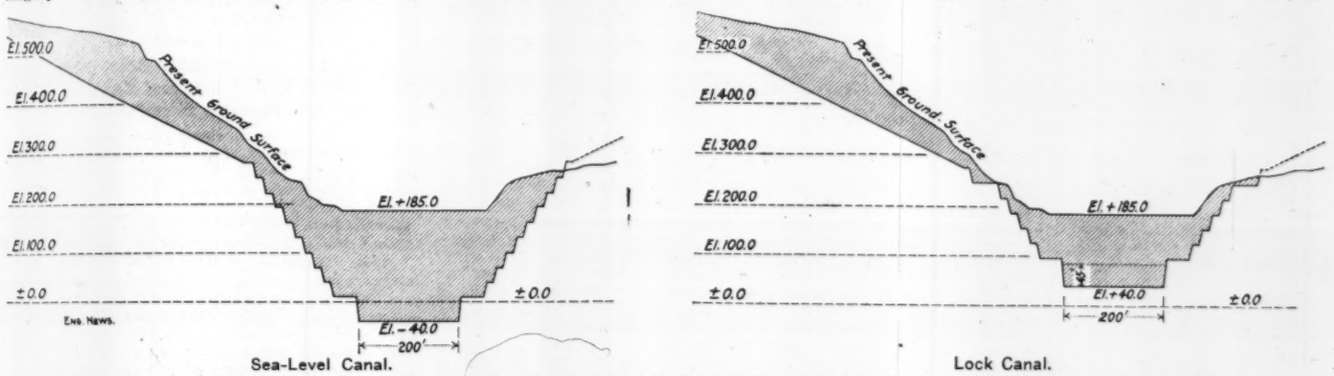
In the lock-canal section this slope commences at approximate elevation 270 ft. and should also commence at this same elevation for the sea-level section.

Very respectfully,

Lorenzo D. Cornish, C. E.

Beaver, Pa., March 5, 1906.

[Our correspondent is correct. An error was made by our draftsman in making the sea-level section from the official drawing accompanying the Consulting Board's report. On that drawing the rock line was shown, but not located by a dimension line, and it was traced directly from that drawing, and thus placed considerably below its true position. We have made, therefore, a new cut for the sea-level cross-section and show the two sections herewith. It should be added that the contour of the present ground surface is taken from Mr. John F. Wallace's drawing, published on page 228 of our issue of March 1.—Ed.]



Sea-Level Canal. Lock Canal.

COMPARATIVE CROSS-SECTIONS OF DEEPEST PART OF CULEBRA CUT FOR A SEA-LEVEL CANAL AND FOR A LOCK CANAL.

The Over-Registration of Two 4-in. Water Meters on Test.

Sir: In a series of tests, recently made by me, of two water meters, I obtained results which are at variance with my preconceived ideas on this subject. I have always understood that a water meter which had been originally correct would not over-register after use, since the tendency of the mechanism in such a case would be to run slower instead of faster than at first.

The tests referred to were of two 4-in. piston water meters, placed side by side on two parallel 4-in. water pipes, which are connected both above and below the meters into a 6-in. water main. The arrangement is such that water can pass through both meters simultaneously into the main, each meter registering its share of the flow; or either meter may be cut out and the entire flow caused to pass through the other meter. In ordinary use both meters were in service together and the sum of their registrations taken for the total amount of water used. For some time it has been noticed that one meter has shown a much greater registration than the other, although no local cause could be assigned for such difference. In order to determine, if possible, whether the "fast" meter was actually over-registering it was decided to make a test of both meters, using such appliances as were at hand.

The water, after passing through the meters, is conveyed through a cast-iron main to a concrete reservoir, situated at an elevation about 150 ft. higher than that of the meters. This reservoir was used as a measuring tank; the water level therein was determined both before and after each test and the difference in height multiplied by the area of the reservoir to ascertain the volume of water received therein during the test.

Before beginning operations both the inlet and outlet valves were closed, the height of water in the reservoir was noted at the time and also after 24 hours. At the expiration of this period the water level was found to be the same as at first; this was considered a satisfactory test of water tightness. In the several tests that were made the water in the reservoir was brought to about the same stage in order to obtain uniformity in local conditions of measurement.

The meter first tested was the "slow" meter; for convenience it was called No. 1, the other being designated as No. 2.

The results obtained are shown in tabular form below:

Duration of test.	Reservoir measurement.	Registered measurement.	Ratio of meter record to reservoir measurement.	Remarks.
	Cu. ft.	Cu. ft.	Per cent.	
5 hrs. 15 min.	3,723	3,790	101.8	Meter No. 1
5 hrs. 30 min.	4,034	4,120	102.1	Meter No. 2
4 hrs. 00 min.	3,138	3,270	104.2	Meter No. 2
6 hrs. 50 min.	4,480	4,670	104.2	Meter No. 2

The two meters tested have been in use about five years. Comparing the results of the two last tests with the others a difference is seen which is too great for good practice. As the measurements were carefully made, I am at a loss to account for the difference. The meters are apparently in good condition and of standard make.

I would be glad to know if any of the readers of Engineering News have had similar experience in making meter tests.

Yours truly,

S. H. Lea.

Sturgis, S. Dak., Feb. 26, 1906.

Leveling with a Transit with the Horizontal Wire Out of Adjustment.

Sir: The letter from Rae & Collins which you published in your issue of Feb. 15, 1906, reminds me of a bit of level work which I did two or three years ago while employed on the corps of the Chief Engineer of a large railway system, and which I believe might be as interesting to many as the idea put forth in the letter mentioned.

I had a survey to make at a crossing of two railways for the purpose of preparing plans for and estimates of cost of separating the grades of the roads, and I took with me a transit, with level tube on telescope, for both transit and level work. The work was of course some distance from headquarters, and at a little town where I did not care to stay longer than necessary. After finishing the transit work which I did first, I had what I thought was just about time to do the level work before a certain train which I wished to take back to headquarters was due. I tried the adjustment of horizontal wire of transit for level work and found it out by that amount which would give a rod reading of 0.029 ft. less than the correct reading on a 300-ft. sight. In other words, by the two peg method, using two points on the top of track rail which were 300 ft. apart, I found in a very few moments that the line of collimation was deflected downward 0.029 ft. in 300 ft. I did not want to take time to adjust the horizontal wire and miss the train and have to "lay over" in that town, so I merely went ahead with the level work, reading the rod to the nearest 0.01 ft. without target and taking turning points

about 400 ft. distant. On every reading I added to the actual rod reading 0.01 ft. for each 100 ft. between instrument and rod (theoretically, $\frac{0.029}{3}$ ft.) There was enough of that work, up and down both roads and on Y connections, to amount to between two and three miles of leveling. I found I had time at the end to check back on initial B. M. and did so, missing an exact check by 0.02 ft., which satisfied me for that particular job, as far as accuracy was concerned.

I have found so little level work that had to be done with a transit that it has not seemed worth the time and trouble to adjust a horizontal wire in a transit for that purpose.

Yours truly,

W. E. Miller.

Northwestern Elevated R. R. Co.,
Superintendent's Office, Chicago, Ill., Feb. 28, 1906.

The Salton Sink Problem.

Sir: Commenting on the article about the Salton Sea trouble in your issue of Feb. 22, 1906, in which you use among other sources of information an article in "Out West," written by me:

The 10,000 which I gave as the probable population of the Imperial Valley rests principally on common report. However, the rapid growth of the valley—about 2,000 per year up to last summer, when the canal troubles discouraged it—would make even accurate estimates differ considerably from each other if made a short time apart.

The Mr. Tolin mentioned was the foreman in charge of the sixth attempt to turn back the Colorado River into its old bed. The engineer in charge of this attempt for Mr. Randolph was F. S. Edinger, of San Francisco. Both he and Mr. Tolin are entitled to great credit for the way in which they pushed this work. While the attempt failed, this was not due to any lack of energy on their part. The immediate cause of failure was an extremely high flood which entirely covered the work before its completion. However, in my opinion (expressed to Mr. Tolin before the flood occurred) the plan chosen would not have succeeded even if no such flood had occurred.

From a report to me on conditions at the intakes on Feb. 18 a force of about 140 men is being employed on a seventh attempt to control the river, the location of which is near the junction of the third intake with the main canal. This work is under the direct supervision of C. R. Rockwood, Chief Engineer of the canal system for several years past, and has not yet reached the state where it is subjected to any trial or test. The permanent headgates are now under actual construction at the only proper site—the rocky point on the river just above the upper intakes—but their progress to date makes their completion by the first of April seem quite unlikely.

The loss of the Southern Pacific Railroad Co. from the formation of the Salton Sea can only be guessed at, but is probably much nearer to $1,000,000 than $500,000. This opinion is based on a consideration of the large work-train and labor force employed at Salton for a long period, much of the time nights as well as days; and on not only the 40 miles of new permanent track just put in use, but also on the many temporary tracks which have been built, used for a short time, and then abandoned only after strenuous and costly efforts to protect them by bagging and riprap had failed. In addition to the railroad company's loss at Salton, a large amount of their money has been expended by the canal company in endeavors to exclude the Colorado River from the intakes. The railroad company's loss will not terminate with the completion of the higher new line, as the increased length of main line will cause at least some increase in the cost of carrying traffic, and the maintenance of the new line will be more expensive than that of the old, both because of its increased length and because its nearness to the foot-hills makes it more exposed to washouts.

Your comments on my article do not make it clear that in my opinion the evaporation can never equal the inflow. The waters of Salton Sea would rise to about 30 ft. above sea level and flow off to the gulf long before sufficient surface-area had been attained to give an evaporation equal to the inflow.

In connection with my belief, quoted by you, that the river will be turned back into its old bed in the not distant future, I may add that last October I made an offer to do this on the basis of "no cure, no pay." While passing through Los Angeles I was sent for by Mr. Epes Randolph, president of the canal company, and asked to make a proposition to turn the Colorado River back into its old bed. Some days later, after a repetition of his request, I gave him a written offer to do the work on a contingent basis: to receive no payment until the river was successfully turned, in which case I was to receive $135,000. In addition, I was to have free use of such plant and materials as were on the ground or then in transit. The plant was inadequate and the materials only brush and piles, but their use would have permitted an immediate beginning of the work. Though the price was a contingent one, Mr. Randolph thought it too high, and declined to consider it unless I would agree to couple with it a forfeit or penalty of $135,000 should I not succeed in turning back the river within 90 days. Such a betting against odds not being attractive to me, the negotiations dropped.

I still believe that the Colorado River can be replaced in its old bed, but do not believe that the canal company will be successful in doing so until it realizes the necessity of more drastic measures and of better engineering methods than it has yet employed.

Very truly yours,

Edwin Duryea, Jr., M. Am. Soc. C. E.

Mutual Bank Bldg., San Francisco, Cal., Feb. 27, 1906.

The "Francis Turbine" a Misnomer.

Sir: On page 78 of your issue of Jan. 18, 1906, you published a review of Mr. Thurso's new book, "Modern Turbine Practice and Water Power Plants," by Prof. Storm Bull, in which he stated that "both the European inward flow turbine and the American turbine are modifications of the original Francis turbine."

For one, I would like to know on what authority such a statement is put forth in an educational article of considerable importance. It was my good fortune to know Mr. Francis well for the last forty years of his life; to have made patterns of parts of turbines of his design under the Boyden license to the Lowell Manufacturing Companies—but in no way of his own invention or origination. In point of fact, he gives the credit of invention of all the turbines with which he, as engineer of these companies, had anything to do, up to the year 1870, to Mr. Uriah A. Boyden, "an eminent hydraulic engineer of Massachusetts," and to Samuel B. Howd, of Geneva, N. Y., the patentee of the United States wheel, so-called. The Howd, patented in the year 1838, was the real precursor in this country of the inward flow and discharge class of turbines, having a series of fixed guides around the outside of the runner to give the water a tangential direction upon the edges of the buckets of the rotating element of the turbine. This part of the machine consisted essentially of two horizontal rings, between which were fixed the buckets—the upper one, usually called the crown, having arms and a hub fitted to a vertical shaft. The gate of the Howd was a plain cylinder, shutting down outside of the guides.

Mr. Boyden's improvements in turbines consisted chiefly in modifications of the French Fourneyron turbine—outward flow and discharge—and the American turbine of Howd—inward flow and discharge. He moved the gate of the Howd from the outside of the guides to the inside—between the guides and the buckets. He also claimed making the rims or crowns "flaring toward the axis of the wheel," and leaning the buckets to prevent the deflection of the streams into the space between the bottom edge of the gate and the crown of the wheel. This he called a "hydraulic motor." The outside discharge, alone, was designated by him with the dignity of "turbine." One of these old motors has been in use in the old Gay, Silver & Co. machine shop at North Chelmsford, Mass., since 1854—is driving the machinery to-day.

On page 69 of your same issue (Jan. 18, 1906) you say of the power plant of the Concord Electric Co. that "the turbines are of the Francis central discharge type." If I read the illustrations correctly, they are of the Howd-Obenchain type. That is, they receive the water on the outer edge of the bucket, as did the Howd wheel. The bucket is so shaped, however, that there is a very small central discharge (directly towards the shaft), a much larger discharge directly downward (as the Fontaine, or parallel with the axis of the shaft) and a lesser amount outward at an angle of 45°, more or less. To my certain knowledge, Mr. Francis never approved of a double curvature bucket (the inward and downward discharge—in fact, persistently distrusted its utility until compelled to admit it by the results of his own experiments upon two of that class of turbines, in 1869-70. The new type of wheel experimented upon was, for years, called by the inventor, the "Union turbine," because of the fact that it received the water on the outside, as did the Howd, discharged about 35% of it toward the shaft, same as the Howd, the other 65% downward, as the "parallel flow" of the French Fontaine; a combination of two old and well-known types of runner. This was accomplished by the removal of the bottom ring and by utilizing the area under it for the necessary bucket-section of the Fontaine part, and the discharge area for the additional amount of water applied. The central discharge part of the bucket, in horizontal section, was described as of parabolic outline, the face the concave side. The bottom element of the bucket was formed by revolving this curve on an axis in line with the guides and opposite the bottom edge of the central discharge; a bucket of double curvature—"paraboloidal in form." Thus far, to all intents and purposes, this description applies to the Concord Co.'s runners, in so far as that part of the bucket exactly under the crown is concerned—with inward and downward discharge; then outside of that line is the Obenchain "little giant" adjunct, curving outward and upward, with the outward angular discharge—say, "45°, more or less." This description applies to [illegible] of most of the present-day American turbi[illegible] of the European make.

Mr. Hiram F. Mills, H. E., experimented [illegible] of the two above-mentioned turbines, finding [illegible] of over 82%. Mr. Francis could not be [illegible] such results could be possible with such [illegible] of runner. Mr. Boyden's theory, and that [illegible] engineers, up to the above-named date, [illegible] water must not be deflected from the [illegible] passing through the turbine. To satisfy hi[illegible] pro and con, Mr. Francis went over all [illegible] parts of the entire testing apparatus, tak[illegible] ments with his own staff of assistants. To [illegible] of one of the staff, he was heard to reply, [illegible] be any mistake about it now." On submittin[illegible] to Mr. Boyden, Mr. Boyden said, "Impossibl[illegible] machine of the same size (42-in.) was sub[illegible] Francis with testing apparatus suggested [illegible] some seven months later. The second [illegible] nearly 2% better results than the test on th[illegible] For the next 25 years, this combination [illegible] standard of the Lowell mills.

The only possible reason for calling any t[illegible] "The Francis Turbine," to the best of my knowled[illegible] belief, is this (which is almost as far as possi[illegible] from a good reason): The Lowell Manufacturing Co[illegible] purchased the right to use all of Mr. Boyden's [illegible] on turbine water wheels for the city of Lowell [illegible] their engineer, Mr. Francis caused to be built and installed in the Boott Cotton Mills of that city, in 18[illegible] two of the United States or Howd wheels, as modified by the Boyden patents, except the leaning of the buckets and guides. One of these (Boyden "hydraulic motors") was tested in the most thorough and careful manner for power and efficiency—the particulars of which test were published in Mr. Francis' great work, "Lowell Hydraulic Experiments." In that work he gives all the proper credits as before stated. In a foot-note he says, "Gen. Poncelet, of France, proposed a similar wheel in all the essential particulars in 1826."

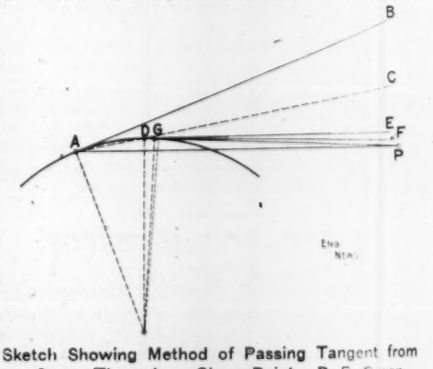
Asa M. Swain.

North Chelmsford, Mass., Jan. 26, 1906.

Projecting a Tangent Through a Given Point; Shifting the P. C. C. in a Compound Curve to Make the Curve Pass Through a Given Point.

Sir: I have read with considerable interest various solutions of the problem of passing a tangent from a curve through a given point. The solutions given are beautiful and could be used if necessary, but they require too much time and labor, when you are actually at work on some busy road where you generally have more work than time. Why this problem should be considered difficult I cannot imagine, as in the field any first-class instrumentman would solve it practically in five minutes without use of tables or formulas. I send you a method which is very generally used, and while theoretically not exact, it is practically correct, and is being used every day. (See sketch herewith.)

We will suppose that the curve is being run in the direction A B and desire to pass a tangent through point P. As a rule, the point of tangency can be guessed



Sketch Showing Method of Passing Tangent from a Curve Through a Given Point.—P. E. Green.

within a couple of degrees, though I have used a much wider angle in the sketch. Set up transit at A, vernier set so that it will read 0 when telescope is on tangent A B. Turn the angle B A P, advance on the curve one-half of the observed angle, i. e., ½ B A P = B A C; set up transit again at D and repeat process. If you have made a good guess as to where the tangent ought to be, this will often place you within a tack head of the point P when the second tangent is turned, and it rarely requires more than two setups of the transit to find the required point G.

Yours truly,

G.

Chicago, Ill., Feb. 3, 1906.

Sir: The following is another solution of the problem of projecting a tangent from a curve through a fixed

point (Dec... 1905, p. 633; Feb. 1, 1906, p. 130). No doubt ... a common method of solution, but I have nev... it before. Its simplicity commends it. It is equa... licable if the given point C falls without A B.

In the sk... Fig. 1 herewith) let the known radius of

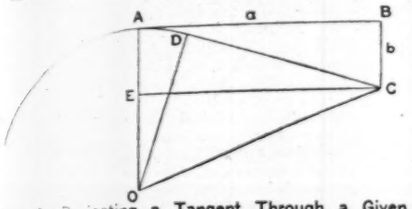


Fig. 1. P...jecting a Tangent Through a Given Point.—D. D. Stiltz.

curve be R. Point A on the curve is assumed as starting point. A B and B C, equal and parallel to E C and A E, respectively, are determined on the ground. Call A B = a; B C = b. Angle A O D is required.

$$\text{Angle A O D} = \text{A O C} - \text{D O C}.$$

$$\tan \text{A O C} = \frac{\text{E C}}{\text{E O}} = \frac{a}{R - b}$$

$$\cos \text{D O C} = \frac{\text{O D}}{\text{O C}} = \frac{R}{\sqrt{a^2 + (R - b)^2}}.$$

These angles determine A O D.

Daniel D. Stiltz.

Howard Butte Co., Cal., Feb. 9, 1906.

Sir: I notice in your issue of Feb. 1 a solution of the old problem "To pass a tangent from a curve through a given point." Having dealt with this problem frequently in practice, I give you herewith my solution of the much-discussed but simple problem.

In the sketch (Fig. 2) let A B H be the given curve,

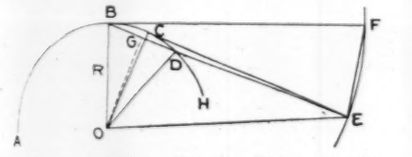


Fig. 2. Projecting a Tangent Through a Given Point.—G. F. Syme.

and E the given point. We seek the point of tangency C or the angle B O C.

Solution—From any point B on the curve turn tangent B F, so as to hit as nearly in the required direction as may be estimated. If the point E is visible from B, measure B E and angle F B E. If E is not visible, measure to any point F on the tangent, also measure F E, and angle B F E; and calculate angle F B E and side B E. (In practice it is usually sufficient to take point F opposite to E, assuming that B E is equal to B F, which is measured, and figure angle F B E by linear deflections, or by bisecting the chord F E.) Draw O D; then

$$\text{D B O} = \text{O D B} = 90° - \text{F B E}.$$

$$\text{B D} = 2\,R \cos \text{D B O}.$$

Draw C E. Now C E and B E, being a tangent and a secant meeting at E we have,

$$\text{C E} = \sqrt{\text{B E} \times \text{D E}}, \text{ and } \text{D E} = \text{B E} - \text{B D}.$$

Draw O E. In the right-triangle O C E we know O C = R, and we have found C E, then find O E and angle C O E. In the triangle B O E we have

$$\sin \text{B O E} = \frac{\text{B E} \sin \text{O B E}}{\text{O E}},$$

and

$$\text{B O E} - \text{C O E} = \text{B O C},$$

which is the angle required.

Another interesting problem which I sometimes have occasion to use in railway location is the following:

Let H B D be a given compound curve and let it be required to shift the P. C. C. so that without changing

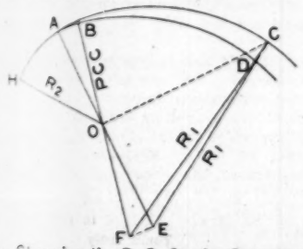


Fig. 3. Changing the P. C. C. of a Compound Curve to Make the Curve Pass Through a Given Point. —G. F. Syme.

radii, the new curve will pass through the point C at a given radial distance, D C, from any point D on the original curve.

Draw O C. Now in the triangle O F C the angle O F C is known and F C = R_1 + D C and F O = R_1 − R_2, hence

$$\tfrac{1}{2}\,\text{F O C} + \tfrac{1}{2}\,\text{O C F} = 90° - \tfrac{1}{2}\,\text{O F C},$$

$$\tan \tfrac{1}{2}\,(\text{F O C} - \text{O C F}) = \frac{\text{F C} - \text{F O}}{\text{F C} + \text{F O}} \tan \tfrac{1}{2}\,(\text{F O C} + \text{O C F}).$$

Whence we find angles F O C and O C F. Then

$$\text{O C} = \frac{\text{O F} \sin \text{O F C}}{\sin \text{O C F}}.$$

Now in the triangle E O C we know the three sides, so we can find angle E O C, and F O C − E O C = F O E = A O B.

Yours truly,

Geo. F. Syme.

Spruce Pine, N. C., Feb. 10, 1906.

Sir: In some of your recent issues the problem of running from a given curve a tangent that shall pass through a given point has been discussed. The last solution given (February 1) is certainly very awkward and cumbersome, both from a theoretical and from a practical point of view. Problems of this kind can usually be solved either by the "brute-force" method or by some artificial method that will reduce the field work or the computations or both. The "brute-force" method consists in measuring whatever data are necessary, and combining them directly by the elementary principles of geometry, so as to obtain the solution. It possesses the evident advantages, as you say, that it does not require the use of books of formulas, and that it will occur to any one fairly familiar with geometry. In some cases, however, a more artificial method, if easily obtainable, is a great saver of time, and often diminishes the probability of error. Below is given the solution of the problem in question both by the "brute-force" method and by another, much simpler method.

1.—Brute-Force Method.—In the accompanying figure, A T D is the given curve (radius C A = r), O the given point, and T the required point of tangency. Let A be any convenient point on the curve, k its distance from O, and M the angle between A O and the tangent at A. If O is visible from A, both k and M may be measured directly; otherwise, they must be determined by a random line or a traverse. The rest of the notation is plainly shown in the figure, the problem being to compute the angle B A T, or P, to locate T.

In the triangle A C O, in which N = 90° − M, angles K and R can be computed by the formulas

$$\tan \tfrac{1}{2}\,(\text{K} - \text{R}) = \frac{k - r}{k + r} \cot \tfrac{1}{2}\,\text{N} \quad \ldots\ldots(1)$$

$$\text{K} = (90° - \tfrac{1}{2}\,\text{N}) + \tfrac{1}{2}\,(\text{K} - \text{R}) \quad \ldots\ldots(2)$$

$$\text{R} = (90° - \tfrac{1}{2}\,\text{N}) - \tfrac{1}{2}\,(\text{K} - \text{R}) \quad \ldots\ldots(3)$$

Triangle C A O:

$$n = \text{C O} = \frac{r \sin \text{N}}{\sin \text{R}}.$$

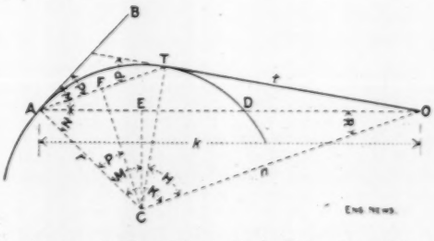
Triangle C T O:

$$\cos \text{H} = \frac{r}{n} = \frac{\sin \text{R}}{\sin \text{N}} \quad \ldots\ldots(4)$$

Finally,

$$2\,\text{P} = \text{K} - \text{H}; \quad \text{P} = \tfrac{1}{2}\,(\text{K} - \text{H}) \quad \ldots\ldots(5)$$

2.—Method by Auxiliary Angles.—The second method is exceedingly simple, and very convenient for logarithmic



Projecting a Tangent to Pass Through a Given Point; Two Methods of Solution.—A. Llano.

work. It is as follows: Let two auxiliary angles X and Y be computed from the relations

$$\sin^2 \text{X} = \frac{2\,r \sin \text{M}}{k} \quad \ldots\ldots(6)$$

$$\tan \text{Y} = \frac{\sin \text{M}}{\cos \text{X}} \quad \ldots\ldots(7)$$

Then,

$$\tan \text{P} = \frac{\sin \text{M} \sin \text{Y}}{\sin (\text{M} + \text{Y})} \quad \ldots\ldots(8)$$

This formula is derived in the following manner: The tangent t is a mean proportional between O A and O D; that is, between k and (k − 2 r sin M); therefore,

$$t = \sqrt{k\,(k - 2\,r \sin \text{M})} = k\sqrt{1 - \frac{2\,r \sin \text{M}}{k}}$$

or, [formula (6)],

$$t = k\sqrt{1 - \sin^2 \text{X}} = k \cos \text{X} \quad \ldots\ldots(9)$$

Triangle A T O:

$$\frac{t}{k} = \frac{\sin (\text{M} - \text{P})}{\sin \text{A T O}} = \frac{\sin (\text{M} - \text{P})}{\sin \text{P}} = \sin \text{M} \cot \text{P} - \cos \text{M};$$

that is, [formula (9)],

$$\cos \text{X} = \sin \text{M} \cot \text{P} - \cos \text{M},$$

whence

$$\cot \text{P} = \cot \text{M} + \frac{\cos \text{X}}{\sin \text{M}},$$

or [formula (7)],

$$\cot \text{P} = \cot \text{M} + \cot \text{Y} = \frac{\sin (\text{M} + \text{Y})}{\sin \text{M} \sin \text{Y}},$$

and, therefore,

$$\tan \text{P} = \frac{\sin \text{M} \sin \text{Y}}{\sin (\text{M} + \text{Y})},$$

which is formula (8).

Antonio Llano.

Scranton, Pa., Feb. 16, 1906.

[The above letter offers an excellent contrast between Mr. Llano's ingenious "artificial" solution and what he pleases to call the "brute force" method. The former is algebraic in character where the latter is arithmetical, and on seeing them in direct contrast above, we are strengthened in our belief that the latter is the method for practical use.—Ed.]

Notes and Queries.

C. R. D. desires a formula for computing the cubic contents of masonry in groined arches where the arches are at right angles to each other, are of unequal span and have various arch curves, semicircular, semi-elliptic, parabolic, etc.

M. & M., St. Cloud, Minn., write:

The bed of a meandered lake is to be divided among the adjoining land owners by running lines from the intersection of property lines with the meander lines to the center of the lake. What is the proper method of determining the center of the lake? Can it be determined mathematically?

Mr. Geo. W. Tillson, M. Am. Soc. C. E., Chief Engineer of the Bureau of Highways, Borough of Brooklyn, New York City, informs us that there must have been a mistake in the item published in our issue of Feb. 15, 1906, to the effect that bonfires cause a heavy yearly damage to asphalt pavements in Brooklyn. During the past year, he states, Brooklyn paid out not more than $100 for such repairs.

In a recent specification for excavating and grading on some work in the far North, it was provided that all material which could not be handled with a plow and three teams should be classed as loose rock. As work was carried on during the winter, the "earth" could not be plowed and it was therefore classed (and paid for) as loose rock. A desire for harmonious relations and a continuance of work led to the agreement being made without friction between the engineer and contractor, but under other conditions there might have been a controversy and a lawsuit over the question whether earth could be transformed to rock within the meaning of the specifications merely by being frozen.

WATERPROOF TRANSMISSION ROPE is being introduced by the American Manufacturing Co., of New York, N. Y. The waterproofing treatment was developed by long experiment, under the supervision of Mr. J. B. Upright, superintendent of the company's Brooklyn mills. The rope has been tested by exposure and by running test, with satisfactory results. Pieces hung in the water of the East River for extended periods of time show no deterioration or appreciable absorption. A combined exposure and running test was afforded by a drive on the roof of one of the mill buildings on the bank of the East River; this drive consists of ten 1¾-in. ropes, and extends nearly the full length of the roof, 225 ft. This rope shows no more wear, after running more than a year, than ropes working under the most favorable conditions in the mills. The waterproofed rope becomes smooth and polished after running some time, the depressions of its surface being filled by the waterproofing. The treated rope is about 2% heavier than untreated rope. Its principal use will probably be for rope-drives exposed to the weather. The company is prepared to make coils of transmission rope up to 10,000 ft. long without a splice.

A NEW HIGH-EFFICIENCY INCANDESCENT LAMP has been brought out by an Austrian inventor, Kuzel. The lamp shows a current-consumption of about 1 watt per candle, a remarkable uniformity of light during its life, and a long life. A number of the lamps has been made for testing in sizes from 12 to 40 c. p., at about 30 volts normal pressure. These lamps showed an average life exceeding 1,500 hours, a power-consumption close to 1 watt per candle (in some slightly lower and in others slightly higher), and sustained both their candle-power and their efficiency throughout their life. It is claimed these lamps can be made for 110 volts, but no such lamps have yet been submitted to test. The filament is probably metallic. It is often self-healing when burned through at one point. The cost of manufacture is claimed to be not materially higher than that of the ordinary carbon-filament lamp, and the raw materials are said to be common and cheap.

EXPERIENCES IN WATER-PROOFING CONCRETE, U. S. FORTIFICATION WORK.

The extensive use of concrete in constructing coast fortifications and the necessity of having many of these structures, such as magazines and encasements, water-proof and damp-proof, have led the U. S. Army Engineers in charge to study various ways of water-proofing concrete with unusual care. In appendix in Technical Details in the Annual Report of the Chief of Engineers for 1905 a number of results of these studies are given, and because of the general interest in and importance of the subject, we abstract the more noteworthy ones for publication in Engineering News.

DEFENCES OF THE COASTS OF MAINE AND NEW HAMPSHIRE.

(Officers in charge, Maj. S. W. Roessler and Lieut. Col. W. M. Black, Corps of Engineers.)

In constructing two 6-in. batteries in this district during the past fiscal year the following methods were used to prevent leakage in the rooms under the traverses:

(a) The entire room cover was divided into blocks believed to be small enough to expand and contract under ranges of temperature from 90° to 20° F., without cracking, with well-defined planes of weakness running parallel with the parade wall of the traverse.

(b) The slope of the top surface was made continuous to the ridge, and the surface was troweled to a smooth finish.

(c) The top surface was ridged along the upper edges of the planes of weakness to induce a flow of water reaching the concrete away from the anticipated cracks.

(d) Flashings of sheet iron were built in the blocks so as to form gutters in the planes of weakness, so sloped as to deliver the water carried inside the walls.

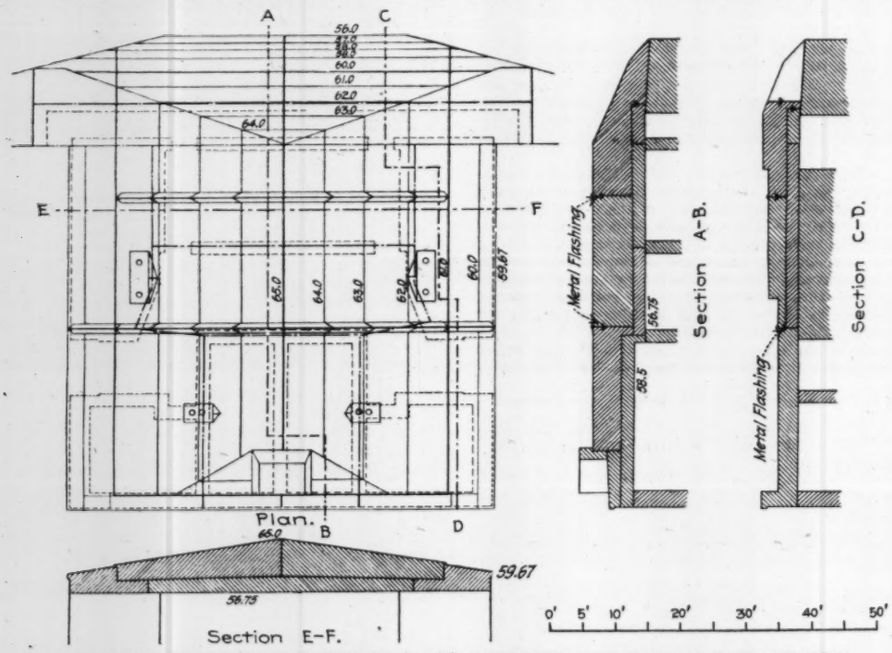
(e) Over the top surface in one of the traverses was placed a layer of hydrolene B, 1 in. thick, covered, while the hydrolene was hot, by a lapped joint layer of tarred paper to provide a better bearing surface for the superposed materials. After the hydrolene had set the upper surface of the tar paper was swabbed with hot hydrolene and a layer of hollow tile placed immediately, with the hollows running down the slope, and the interstices between adjacent tiles over planes of weakness filled with hydrolene. An angle iron, with its top flush with the lower side of the tile hollows, was bolted along the bottom of the water-proof cover on each side of the traverse roof to prevent the tiles from slipping. The earth fill was placed on the tile. The cost of the hydrolene, paper and tile in place was 79 cts. per sq. yd. The other traverse was left uncovered in order to see what leakage would take place without the water-proofing. The arrangement of the blocks, flashings, etc., is shown in the accompanying drawings, Fig. 1.

Hydrolene makes a poor bond with a smooth concrete surface. A good bond can be obtained by first swabbing the concrete with a thin coat of coal tar. The bond between the hydrolene and tarred paper and between hydrolene and tile is good.

The water-proofing above described was placed in the traverse in October and November, 1904, and has been watched closely since. During the winter the temperature fell to 15° F., and during June and July rose to 90° F. The hydrolene did not become brittle in the low temperature, and has showed no tendency to run in the high temperature. In an office test under a pressure of 1½ lbs. per sq. in., temperature of about 70° F., it compressed slightly and squeezed toward the free sides to a limited extent. The finished traverse showed two small leaks in the power-passage side walls before being water-proofed. Since the water-proofing has been in place there have been no signs of leakage.

The melting point of the hydrolene B used was 215° F. When melted the hydrolene is very fluid and requires care in the placing to obtain the required even thickness on the inclined surface. Since the hot hydrolene melts the previous coat upon which it is placed and forms a perfect weld when the old surface is clean, it was found best to flow it on in thin layers. When making a coal tar bond the coal tar is swabbed on the concrete and allowed to cool. The hot hydrolene when placed welds to the coal tar.

Sheet copper has been used for water-proofing over the traverses in several of the batteries of this district. In all of these the copper shows signs of corrosion, and in one finished in 1904, from which the earth fill has been partly removed, the original finished surface has disappeared from the copper and pitting has begun. In several the soldered seams have opened at points, apparently due to expansion and contraction under temperature changes, no expansion joints having been provided.



DETAILS OF WATERPROOF CONSTRUCTION OF CONCRETE TRAVERSES, MAINE AND NEW HAMPSHIRE COAST FORTIFICATIONS.

In the 3-in. battery at Fort Williams the water-proof coat was made as follows: The concrete was first coated with hot coal tar. On this were placed three layers of two-ply tarred paper coated with hot coal tar. On this was laid 16-oz. sheet copper, with folded lap joints, which were soldered on the outside of the fold. The cost of this water-proofing was $3.22 per sq. yd.

To test the durability of copper when exposed to the action of salt water two test pieces of 16-oz. commercial sheet copper were used. One piece 4 ins. square was suspended horizontally in air. A second piece of the same sheet of copper was soldered into box form, with an inclined bottom resting on concrete, and one free side, to simulate the condition in a traverse roof. This box was filled with sand, provision being made for free drainage. Each test piece has been wetted daily with sea water since Jan. 21, 1905. The test piece in air showed no corrosion at first. On July 10, 1905, it was found to be coated with verdigris, though apparently not much pitted. The test piece under sand was examined July 10. The sides are badly corroded and in places pitted. The inclined bottom was bright and clean. The experiments are being continued. The tests were made because of very rapid corrosion of copper-wire window screens in air sheltered from rain, observed by the writer on the Isthmus of Panama.

In the 6-in. battery, of which the traver[s] left uncovered and without water proofing[,] precautions taken with the concrete seem [to] reasonably satisfactory. The past winter [was] one of the most severe experienced in th[is] many years. There was an unusual amoun[t] in the month of June, and since the latter [part] month the temperature has been high, with [rains] at intervals. The joints at the planes of w[eak]ness opened according to expectation, but no [large] have appeared. During rains water flows [in] ends of the plane-of-weakness joints above [the] the flashings and not below.

One small leak has appeared in the ce[iling] ceiling of the magazine immediately under [the] section of two planes of weakness in the ove[r] No other leaks have appeared in the roo[m]. In the powder-passage during rains, damp spots s[how] walls near the ends, apparently due to imper[fec]tions in the concrete in or near the curved projection[s] of the traverse cover over the parapet at the sides of the two emplacements.

In using wet concete great care must be taken to prevent separation of the fine and coarse ingredients, and loss of water-laden cement, if the haul from the mixer to the site be long. If there be leaks in the concrete forms there seems also to be a tendency to form channels in the interior of the concrete mass while being placed. At Fort Preble, while the concrete of one of the massive traverse side walls was under construction a flow was noticed through the concrete form at one spot which persisted until the entire mass had been placed and set.

WATER-PROOF PLATFORM PAVEMENT.—In some of the older contract-built batteries the loading platforms were badly cracked and leaky. These are being repaired. The old surface is being broken up and removed. Lines of hole 6 ins. in diameter are drilled to the required depth, with intervals of 9 ins. c. to c. of holes, and with a distance of about 2 ft. between the lines. The concrete left in place is then removed by wedging. Though the concrete is quite hard, this is accomplished without difficulty. The total cost of removing the old surface is $2 per sq. yd.

The remaining bed is then brought to a true surface, having a slope of 1 in. to 5 ft. with fine concrete. The adjacent parapet and traverse walls are undercut for a depth of 6 ins. and a width of 6 to 12 ins. The entire surface is then covered with a ¾-in. coat of hydrolene, which is carried over the entire surface of the undercuts, being there bonded to the concrete by coal tar. On the hydrolene is placed either one layer of tar paper or two layers of hydrex felt. On this is placed hollow tile, bonded to the water-proofing with hydrolene, and with the hollows in line with the slope, but a gutter 6 ins. wide is left along the traverse and parapet walls. Concrete paving is placed over the tiling, and the gutter is covered with an angle iron bolted in place. The cost of the work in the one platform completed is $12.64 per sq. yd.

The object of the tiling is to drain the water-proof layer. The gutter is to permit free expansion and contraction of the pavement and to render the water-proofing accessible along the line of the vertical walls, where failure is most to be expected.

The platform has not been placed long enough to have been tested. The details are shown on Plate F.

DEFENCES OF THE DELAWARE RIVER.

(Officer in charge, Capt. C. A. F. Flagler, Corps of Engineers.)

At Fort Mott the superior crests of Batteries Arnold, Harker and Krayenbuhl were water-proofed with coal tar and sand. The tar was applied hot and spread over the concrete surfaces with rubber squeegees and then sanded. Joints were filled with the hot tar. A surplus of sand was put on and left for a few days and then swept off. Two coats were put on over the traverses and one over the parapets. The total surface covered, two coats, was 14,700 sq. ft., and one coat 19,600 sq. ft., 2½ barrels of coal tar being used, which gives a covering capacity of 2,279 sq. ft. per barrel, one coat. The tar cost $4.25 per barrel, delivered at Fort Mott. The cost, including materials and labor, was $0.0074 per sq. ft., one coat.

In Batteries Arnold and Harker practically all percolation was stopped. The magazines are still damp, however, from condensation during the summer months, and throughout the year from dampness arising from the foundations, which are on a clay stratum, with no underdrainage. In Battery Krayenbuhl only the 6-ft. wide parapet around the circular platforms could be water-proofed, which had very little effect. Most of the leakage in this battery is from water running down the vertical walls, all around the battery, between the concrete and earth embankment.

At Fort Du Pont the superior slopes and all exterior walls of Battery Elder were given two coats of boiled linseed oil for water-proofing, and for coloring the concrete surfaces to relieve the strain on the eyes from sunlight reflected from the natural concrete surfaces.

A NEW FORM OF REINFORCEMENT FOR CONCRETE.

The accompanying illustrations show a new reinforcing bar for concrete construction. As will be seen the novelty consists of a provision for connecting subsidiary reinforcing or web members to the main tension bars at any point without reducing the sectional area or tensile strength of either the main or the connecting bars. The means for accomplishing this desirable result is simply to roll the bars with grooves as shown by Fig. 1, and then press the lips of this groove together to clasp the web member. The idea is clearly shown in the various accompanying cuts, and it is stated by the inventor that the connection is so strong that in all tests so far made an attempt to pull the small bars free has always resulted in the breaking of this bar remote from the main bar.

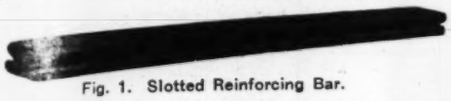


Fig. 1. Slotted Reinforcing Bar.

The drawings Figs. 2, 3 and 4 show the application of the reinforcing bar described to girders, columns and partitions. These illustrations are sufficient to show that the number of combinations is almost limitless. Fig. 2 shows a bar with stirrups attached as would be done in girder reinforcement. It will be noted that the main bar is nowhere reduced in section, and that the stirrups may be attached with any arrangement of spacing desired, that they may be of any length desired and that they may be set at any angle with the main bar that is desired. A point to be noted also is the facility offered for attaching spacing rods either to hold the main bars above the lugging boards or to preserve their distance apart laterally or vertically.

Fig. 3 is a sketch showing the arrangement for column reinforcement, and Fig. 4 is another sketch showing the arrangement for a hollow wall or partition. These two sketches are so clear that extended description is unnecessary.

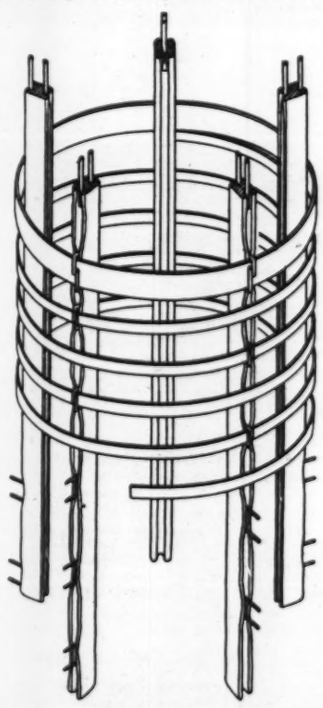


Fig. 3. Reinforcing Unit for Columns.

In conclusion it may be noted that it is possible either to assemble the reinforcement as shown at the shops and ship it to the work, or simply to ship the bars, rods and mesh in suitable quantities and do the assemblying at the site of the work. The apparatus required is very simple, being merely that necessary for binding and cutting the rods and a drop press for clamping together the lips of the grooves in the main bars.

The form of reinforcement described is the invention of Mr. J. G. Golding, of Washington, D. C., well known as the inventor of expanded metal. The Monolith Steel Co., Colorado Bldg., Washington, D. C., is the licensee of the United States patents for this invention.

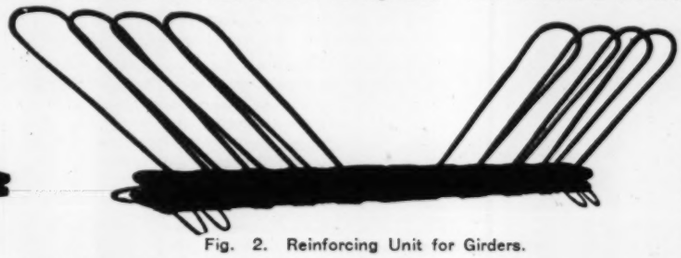


Fig. 2. Reinforcing Unit for Girders.

THE DESIGN OF KNIFE-EDGE BEARINGS.

In our issue of Oct. 26 mention was made of a reader's request for published data as to the allowable load on knife-edges for heavy scales. In response to that request, Prof. Chas. M. Allen, of the Worcester Polytechnic Institute, has called our attention to a series of experiments conducted by Dr. T. C. Mendenhall, formerly the head of the U. S. Coast and Geodetic Survey. These experiments were begun several years ago at Washington, D. C., and were continued in the laboratories of the Worcester Polytechnic Institute. These completed experiments dealt almost wholly with the knife-edge as used on the pendulum for measuring the attraction of gravity, and were not continued, as was the original intention, far enough to secure any definite data on knife-edges used on balances and testing-machines. The general results, however, with certain modifications, will apply to all these cases.

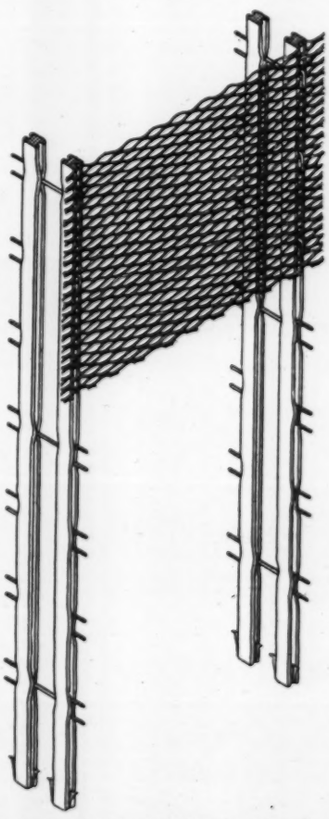


Fig. 4. Hollow Wall and Partition Construction.

The use of the pendulum for determining the constant of gravity at a definite elevation, for use in certain computations in surveying, requires an instrument which is exceedingly accurate. A great deal of this accuracy depends on the construction and material of the vibrating contacts.

The common form of bearing is a linear contact between a horizontal plane surface and a knife-edge. The general custom has been to clamp the knife-edge to the pendulum, allowing it to bear on a horizontal fixed plate. With this method of suspension, any change in the form or character of the knife-edge, due to elastic pressure, is liable to change the results of the experiments very materially, by changing the axis of rotation with respect to the pendulum. All knife-edges are more or less elastic when under pressure, the more perfect the edge the greater the elasticity. The length of the pendulum is greater when in motion than when stationary, due to the centrifugal force. Any regrinding of the knife-edge also changes the length.

A design which is preferable, since it is much less dependent on the shape of the knife-edge for correct readings, involves an interchange of the plate with the knife-edge, the plate being clamped to the pendulum and oscillating on the fixed knife-edge. In the original style, with the knife-edge fixed to the pendulum, the period of oscillation is independent of the position of the knife-edge on the plate, but great care must be taken to adjust the knife-edge at right angles to the axis of symmetry. In the new arrangement suggested, with the two contacts interchanged, the period depends somewhat on the position of the line of contact, but not as much as might be supposed at first thought. A series of experiments made with the adjustment entirely by eye showed a variation from the mean period of less than .000001, which is negligible as compared with the error of observation.

The most important gain in this new form of pendulum is that it makes possible a more complete study of the effect on the vibration period of different kinds of knife-edges, both in material and shape. As long as the knife-edge formed a part of the pendulum this was very difficult and unsatisfactory. With the pendulum constant in mass and configuration, any change in the period will be due to the fixed knife-edge.

In the experiments conducted by Dr. Mendenhall the plate was of agate, as is generally the case, the surface being considered invariable. The knife-edge was of steel on account of its greater ease of manipulation when being ground, than when agate is used. The vibratory period, however, is essentially the same. The angle of the edge was 110° and ground to as perfect an edge as possible. The width of the edge, as near as could be measured by microscopic means, was .001 mm. The period was then found, with the pendulum oscillating on this edge. The width was then increased to about .002 by a light touch of the stone, and the period again found. Periods were also found for other somewhat approximate widths, with results as indicated:

Width of edge	Period.	Gain in length of period.
.001	.5008880	0
.002	.5008839	41
.005	.5008756	124
.0065	.5008503	377
.010	.5007626	1254

This indicates very clearly the important part played by the edge, on the length of the period and shows the importance of having it perfectly ground. A change in width from .001 to .005 mm. changes the period one part in 40,000, an amount entirely outside of a reasonable limit of accuracy.

It is evident that for either vibration use or for simple bearings, as in balances, testing machines, etc., a knife-edge must be sharp enough to be clearly defined and to allow of the necessary angular movement as nearly about a line as possible; while it must also be strong enough to reduce the change of form by crushing, when the strain is applied, to a certain minimum.

There are one or two other things which are against too sharp an edge, but the principal thing, as stated above, is to find an angle which will give a sufficiently well-defined line-edge and which will not crush under the stress to which it is to be subjected, so as to change the edge into a more or less irregular flat surface. An increase in the angle increases the width of its edge. To investigate the effect of the angular variation on the length of the period, Dr. Mendenhall made a large number of experiments, using edges of different angles, each ground to as near a perfect edge as possible. The results follow:

Angle.	Period.
90°	.5008875
110°	.5008880
130°	.5008874
150°	.5008884
160°	.5008852

This shows the required angle to lie somewhere between 110° and 140°. Probably an angle of 130° would prove the most satisfactory, combining as it does, the necessary sharpness (when properly ground) with strength to resist accidental injury or excessive elastic compression.

Steel knife-edges are generally used in pendulum work, but they are much inferior to agate. The brittleness of the latter is more advantageous than otherwise, as a blow will chip it, leaving the remaining portion almost as clean and perfect as before. Steel would be flattened and distorted under similar treatment. Much more difficulty is experienced in grinding agate to a perfect edge, than steel.

The grinding of an agate knife-edge is greatly facilitated by inserting its edge in a heavy tablet of brass and grinding it in place. The tablet should be provided with three feet having hemispherical ends, resting respectively on a conical hole, a V-groove and on a plane.

While the above experiments will be seen to bear chiefly on the knife-edges used in the most delicate instruments of precision, it seems evident that for ordinary knife-edges, such as those in weighing machinery, testing machines, etc., the very obtuse angle is likewise to be preferred.

As to the safe working load per lineal inch which may be placed on knife-edges for such machines, further search for data has been unsuccessful, and we again appeal to any of our readers who may have information on this matter.

FRENCH CARS FOR CARRYING LARGE STEEL PLATES.

The manufacture of steel plates 13.12 ft. in width at steel works in France has raised the problem of the safe transportation of such wide plates of great length over the railways, especially in view of the limited clearance dimensions or loading gage. The Paris, Lyons & Mediterranean Railway has built for this special service a number of steel cars having upright triangular frames to support the plates in an inclined position, and these are described in the "Revue Generale des Chemins de Fer" by Mr. Ch. Baudry, Chief Engineer of Equipment and Traction.

The car, shown in Fig. 1, has plate-girder side sills of fish-bellied pattern, with a lighter center sill and transverse members of I-beam section; diagonal bracing is also introduced in the end panels of the underframe, and large gussets and connection plates are used. Upon the underframe are eight transverse frames; each of these has a vertical steel channel riveted to one of the side sills, which, with horizontal and diagonal angle braces, supports an inclined channel whose lower end is riveted to the top of the other side sill. These frames are about 8.8 ft. apart, with double diagonal bracing in each panel, this bracing being in the plane of the inclined members; they are also connected at the top by a longitudinal steel angle. Brackets on the sill allow for very wide plates, which project beyond the sill. The frames are so designed as to keep the center of gravity of the load as nearly as possible in the plane of the center line of the car. The car is mounted on four-wheel trucks, with arch-bar or diamond frames. Swing bolsters are used, with spherical center-bearings and conical rollers for the side bearings. A nest of four coiled springs is placed at each end of the bolster. Within the inclined channels are wooden fillers projecting slightly beyond the sides of the channels, and upon these rest the plates forming the load.

These cars can carry plates, or bundles of plates, up to 65.6 ft. in length, 2 ins. in thickness and from 6.56 to 13.12 ft. in width. Thicker plates can be carried when the width does not exceed about 12 ft. The plates are secured by the devices shown in Fig. 2. The lower edges of the plates rest on lugs, A, bolted to brackets on the top or side of the sill, as required. At the plates are secured by the clamps, B, are set astride of the inclined channels, and grooves engaging with guide pieces on the of these channels. The screw clamps, C, are both at bottom and top. The lugs, A, placed in three positions (as shown in Fig according to the width of the plates to be ca so as to keep the center of gravity of the approximately within the center line of the The lugs are now made to receive plates 2 ins. in thickness, but larger ones can be for a greater thickness, up to a maximum ins.; the width, however, must be correspondi reduced and would be limited to 6.56 ft. for maximum thickness. These cars can carry loads over the railway systems of France, Swi land, Italy and Germany.

The principal dimensions of these cars are as follows:

Length over end sills	69.35 ft.
Length over spring buffers	69.53 ft.
Width over side sills	6.24 ft.
Height, rail to top of sill	3.45 ft.
Height, rail to top of frames	13.00 ft.
Trucks, wheel-base	5.90 ft.
Trucks, distance c to c	45.92 ft.
Wheels, diameter	2.98 ft.
Journals	5.2x10.4 ins.
Weight of car, empty	45,980 lbs.
Weight of maximum load	88,000 lbs.
Weight, loaded, maximum	133,980 lbs.

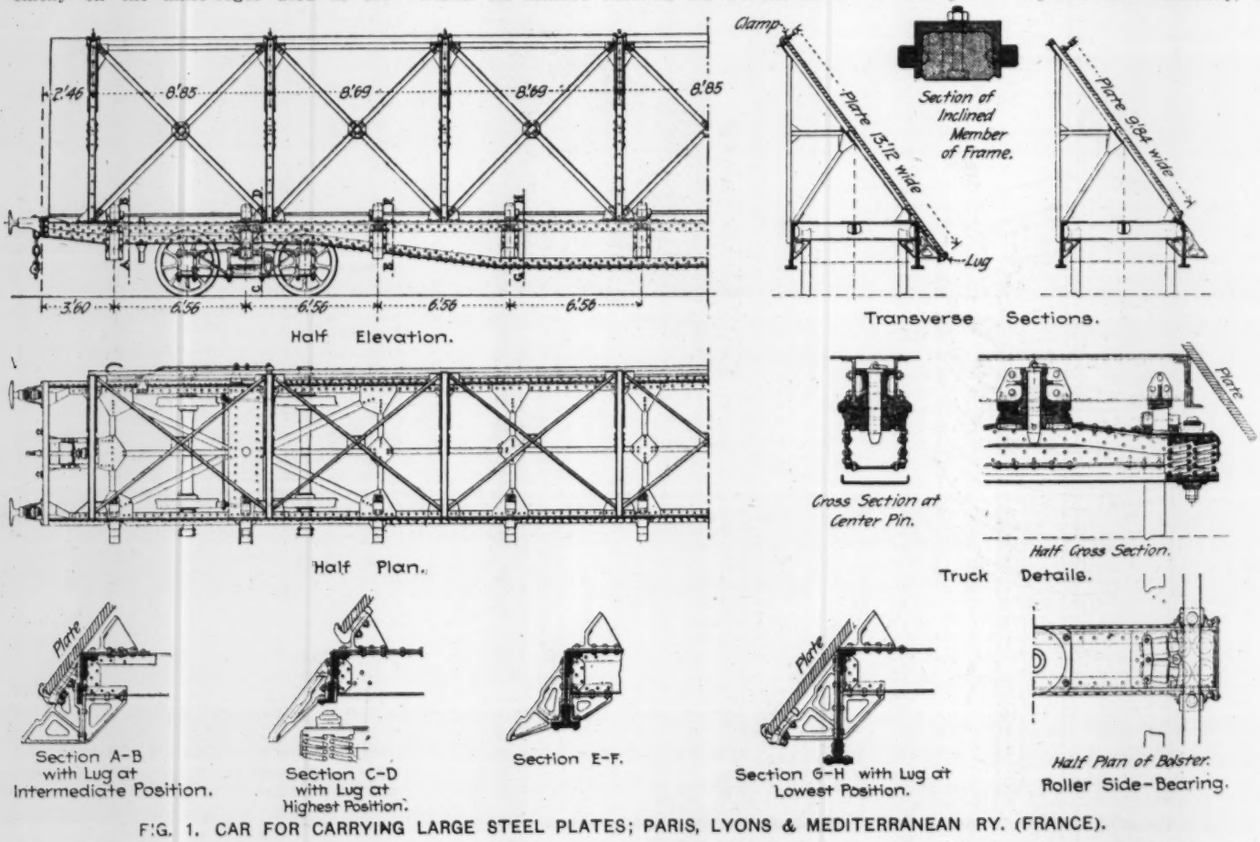


FIG. 1. CAR FOR CARRYING LARGE STEEL PLATES; PARIS, LYONS & MEDITERRANEAN RY. (FRANCE).

A NOTABLE REPORT ON GARBAGE AND REFUSE COLLECTION AND DISPOSAL AT COLUMBUS, O.

At last an American city appears to be well advanced with a plan for working out its garbage and refuse disposal problem on a thorough-going engineering basis. That city is Columbus, O., and its action is all the more remarkable since for some years it dilly-dallied with various much-needed public improvements. Recently, however, it settled down to business, and now it has under construction an extensive sewage purification plant, combined water purification and softening works, and on March 3 an ordinance for a $290,000 bond issue for garbage and refuse collection and disposal was introduced in the city council. This appropriation is based on a report and detailed estimates submitted by Mr. John. H. Gregory, Assoc. M. Am. Soc. C. E., Principal Assistant Engineer, Board of Pub

Service, submitted on Jan. 27, 1906, and subsequently approved by Mr. Rudolph Hering, M. Am. Soc. C. E., of New York City, and Mr. Julian Griggs, Am. Soc. C. E., who until March 1 was Chief Engineer of the Columbus Board of Public Service. The estimates, in particular, deserve attention. So far as we know they are the only detailed engineering estimates of the cost providing a city with a complete plant for the collection and disposal of garbage and rubbish, of the yearly cost of maintaining and operating such a plant, including capital charges. The combined with the careful review of the composition and the probable steam raising quality of the Columbus garbage and

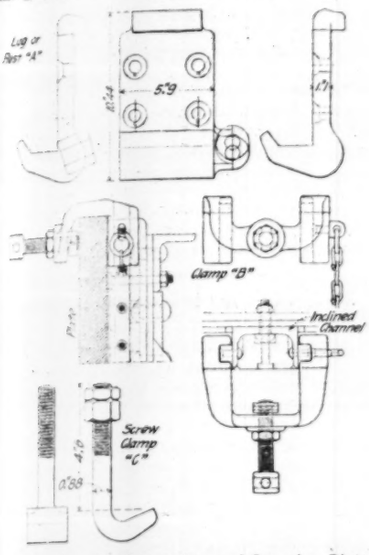


Fig. 2. Devices for Supporting and Securing Plates.

refuse, make Mr. Gregory's report worthy of careful study. By way of preface to further consideration of the report it may be said that his chief recommendations are as follows:

That the city collect garbage, rubbish and dead animals by its own employees, providing ample equipment and stable accommodations for the purpose; that it build and operate a crematory for cremating the material so collected; that the collection of night soil by private scavengers be continued, but that the city dispose of the night soil in connection with its new sewage treatment works; that the present practice of collecting street sweepings and dumping them on low grounds be continued; that the municipal collection and disposal of ashes be postponed; and that municipal collection and disposal of stable manure is neither desirable or warranted.

Antedating Mr. Gregory's report, and anticipating its main general conclusion, was a report made by Mr. Hering on Sept. 19, 1905, shortly after visiting some garbage disposal works while in Europe. In that report Mr. Hering advised the city to collect both garbage and general rubbish (the latter was not being collected then), and, after hauling them to a proper site and mixing them, to dispose of them by cremation. In case it was considered advisable not to collect rubbish at the expense of the city, then Mr. Hering recommended an improved system of garbage reduction. The estimated cost of a garbage and rubbish crematory and building was placed by Mr. Hering at $100,000 to $125,000, which, it will be seen, is considerably below Mr. Gregory's later figure, based on far more complete information.

As a sequel to this report by Mr. Hering the city council took steps which led to the detailed investigation and report by Mr. Gregory.

After reviewing the inadequate and more or less incomparable data on garbage and refuse disposal in other cities, including some figures of gross and per capita cost, Mr. Gregory proceeds with a description of local waste conditions and practices, including sewage and all other classes of municipal refuse. The output of ashes in Columbus is relatively small, on account of the use of natural gas. Garbage and dead animals are collected by the Columbus Sanitary Works Co., the wagon bodies loaded on steam cars, and the cars hauled 4½ miles to an old reduction plant, all under a ten-year contract that expires on April 1, 1906. The contract price for the whole period has been a flat rate of $15,800 a year, which was probably fair at the start, but is believed to be less than cost at present. In 1904 the reported amount of garbage transported to the reduction works was 16,221 tons, the collection and transportation of which, Mr. Gregory says, must have cost $20,000. The per capita contract price for both collection and disposal, assuming a population of 160,000, is less than 10 cts. per capita per year. Under such conditions the collections are now incomplete and the service unsatisfactory. The reduction works, also, in view of the close of the contract period, are out of repair. There have been complaints of pollution of Alum Creek from the greasy water from the digesters, and there have also been complaints of odors from the reduction works.

There is no public collection of rubbish in Columbus at present. Private scavengers remove some, with ashes, and some is thrown into streets and alleys. It is estimated that the citizens pay $30,000 a year to private scavengers for the removal of rubbish alone.

Night soil is removed at night, by private contractors, supervised by the board of health. It is deposited outside the city, wherever permission can be obtained; some is surreptitiously dumped by the roadside. The maximum legal charge for removing night-soil is 10 cts. per cu. ft., and from daily reports to the board of health it appears that during 1904 about 112,000 cu. ft., or 3,900 tons, were removed, at a cost of about $10,000.

Dead animals, collected by the Sanitary Co., aggregate about 350 tons a year, of which 553 are horses.

Under the conditions outlined the cost of refuse disposal, to the city, has been small, but at the expense of a high cost to individuals and a poor service.

The populations and the tonnages of various wastes, both estimated, for 1905 and various future years are given in the report as follows:

	1905	1907	1910	1915	1920
Population	160,000	176,000	202,000	254,000	320,000
Street sweepings, tons	57,300				
Ashes (if natural gas were not used), tons	64,000	70,400	80,000	101,600	128,000
Garbage, tons	17,600	19,400	22,200	27,900	35,200
Rubbish, tons	8,000	8,800	10,100	12,700	16,000
Manure, tons	45,000	47,000	50,000	55,000	60,000
Night soil, tons	3,900	4,500	5,000	5,600	6,000
Dead animals, tons	350	380	420	470	500

The basis for deciding what wastes should be subject to municipal collection and disposal is well put by Mr. Gregory. He would include

all refuse, the accumulation of which would be uncleanly or unsightly, the production of which is practically universal, and the removal of which cannot be better and more economically performed by the individual.

Mr. Gregory points out that the major cost of garbage disposal is the haul. This, after loading, and including the return of the empty wagon, he puts at about 30 cts. per ton mile.

The absolute right of municipalities to exercise police control over garbage collection, in the interest of public health, was confirmed by a decision of the U. S. Supreme Court on Nov. 27, 1905, sustaining ordinances of the cities of San Francisco and Detroit, "granting exclusive contracts for the removal of garbage." [In the case of San Francisco, if we mistake not, the "exclusive" provision was to the effect that all private scavengers must take their garbage to a privately-owned crematory, and pay not to exceed a certain sum per ton for disposal.—Ed.]

The separate collection of garbage and rubbish, notwithstanding British practice to the contrary, is considered imperative in the United States, and particularly at Columbus, whatever the method of final disposal.

At Columbus, the report holds, the only methods of garbage disposal available are cremation and reduction, "either of which is effective and can be conducted without objectionable features." The recently completed reduction plant at Toledo, of the Edson type, Mr. Gregory states, was found by him to be "conducted with remarkable freedom from objectionable features."

Cremation, in theory and practice, is discussed at some length in the report. The absence of coal ashes at Columbus, as in other cities in the natural gas district, gives the refuse a distinctive character. The garbage and dead animals in the refuse delivered to a crematory in Columbus would be from 65 to 70% of the total, instead of 8%, as in England, and

70 to 75% of the garbage will be water, and the calorific value of the remainder will be so low that the garbage cannot be consumed without previous drying or the addition of fuel.

Then follow other data to show how different is the material brought to English furnaces from that to be expected in Columbus, after which Mr. Gregory says:

The calorific value of the combined refuse, garbage, dead animals and rubbish, of which a crematory in Columbus must dispose, will not average above 2,000 B. T. U. per pound of refuse, and the total amount of water, the free water and that liberated by the breaking up of the carbohydrates, etc., will amount to about 0.8 lb. per pound of refuse. The proportion of water will run much higher than this in the summer months and the calorific value will be correspondingly reduced. In burning this low class of fuel a larger percentage of excess of air will be required than with a good fuel, and it is probably that more than 100% excess of air will be required rather than less with 100% excess of air, with perfect combustion and with no allowance for losses by radiation, etc., the maximum furnace temperature possible is 1,100° F. By extracting 25% of the water before burning, the theoretical temperature would be increased to 1,450° F., which is still much below that temperature to which it is desirable to heat the gases, to prevent any possible emanation of noxious fumes.

I am firmly, therefore, of the opinion that additional fuel must be burned in order to reach the desired furnace temperatures, providing that the garbage is not previously dried out by the waste heat from the furnace gases, the expense of which treatment might be greater than the cost of additional fuel.

The evaporatic power of English town refuse is quoted (from Dawson) as from 2 lbs. of water evaporated from a 212° F. per lb. of refuse fuel, for "screened ash pit refuse," to 1 lb. and even 0.75 lb. inferior "unscreened ash pit refuse." These are not the net evaporative efficiencies, available for power production in English furnaces, since from the figures given must be deducted about 0.125 lb. of steam for fan blast and about 0.4-lb. for steam blast for forced draft. In the New York furnaces for rubbish, only, evaporation on test, with fan blast, did not exceed 1½ lbs. of water to 1 lb. of refuse.

At Columbus, even after adding to the refuse the fuel which it appears will be necessary to get a sufficiently high temperature for combustion of the refuse, Mr. Gregory thinks "it is unlikely that an evaporation of more than 0.5-lb. of steam per pound of refuse can be obtained."

Another serious aspect of boiler plants for heat utilization, the report states, and one that "becomes more serious the lower the furnace temperature, is the deposit on the outside of the boiler surfaces and regenerators." This coating has been noted by C. N. Russell, in England, and at the combined sewage and garbage works at Mansfield, O., the deposits on the boiler tubes became so troublesome that the use of the boilers to produce steam was stopped.

Another obstacle to the utilization of heat at the proposed Columbus crematory would be the difficulty of finding consumers for the heat or for power derived from it; the conditions being unfavorable for municipal as well as private utilization. The mechanical equipment of the crematory might be operated by steam therefrom but no considerable revenue could be expected from the sale of such steam. In concluding this portion of his discussion Mr. Gregory quotes approvingly some comments on the unlikelihood of heat utilization from American garbage made in Engineering News for April 6, 1905.

Cremation is considered preferable to reduction, even though reduction would cost less and not be a nuisance, because the city "will be better satisfied in the end to build and operate a crematory, in which all the garbage and rubbish would be burned," and which would be under the full control of the municipality. [From this

remark, and from an expression of doubt as to the wisdom of the recent municipal purchase of the reduction plant at Cleveland, O., it appears that Mr. Gregory considers municipal ownership and operation of garbage reduction works unwise.—Ed.]

Rubbish sorting for the recovery of salable matter, as practiced at Boston, New York and Buffalo, is reviewed in the report, but apparently is not considered with much favor, at least for present adoption at Columbus.

The estimate for night soil disposal, given further on, is based on the continuation of private collection, with disposal into an intercepting sewer, through a roofed chamber, all under city supervision.

Mr. Gregory's "Estimates of Cost and Operation," based on permanent and fireproof construction, only," and including durable works in every respect, are well worth giving in full. They therefore follow:

Estimated Cost of Construction and Equipment for Separately Collecting Garbage and Rubbish and Delivering in Wagons not More Than One Mile from the Capitol.

CONSTRUCTION AND EQUIPMENT.

First Cost:		
Land	$12,000	
Grading and paving	15,000	
Water and sewer connections	1,000	
Stable for 100 horses	40,000	
Wagon sheds	7,000	
		$75,000
Horses and harnesses, 80 @ $250	$20,000	
Garbage wagons, 30 @ 225	6,750	
Rubbish wagons, 15 @ 250	3,750	$30,500
		$105,500
Engineering and contingencies 10%		10,550
Total		$116,050

OPERATING EXPENSES.—1907.

Fixed Charges:		
Interest, 4% on $116,050	$4,642	
Sinking fund, 20-year, 4% bonds	3,897	
		$8,539
Maintenance and Operation:		
Drivers wages:		
Garbage, 19,400 tons @ $0.80	$15,520	
Rubbish, 8,800 tons @ $1.50	13,200	
Keep of horses with stable attendance, 80 @ $200	16,000	
Repairs on buildings, etc.:		
4% on $5,000	$200	
2% on 47,000	940	
	1,140	
Repairs and renewals on stock and equipment, 12% on $30,500	3,660	
Foreman, inspector, clerk, and office expenses	3,000	
Superintendent, ½ time	1,200	
		$53,720
Total		$62,259

	Per ton.	Per capita.
Fixed charges	$0.303	$0.049
Maintenance and operation	1.905	0.305
Total	$2.208	$0.354

Estimated Cost of Crematory with Land and Equipment to Consume 175 Tons of Mixed Refuse in 24 Hours.—Buildings Designed for Extension to 250 Tons.

CONSTRUCTION.

First Cost:		
Land	$9,000	
Grading and paving	8,500	
Water and sewer connections	1,500	
Crematory and stack	134,000	
		$153,000
Engineering and contingencies 10%		15,300
Total		$168,300

OPERATING EXPENSES.—1907.

Fixed Charges:		
Interest, 4% on $168,300	$6,732	
Sinking fund, 20-year, 4% bonds	5,652	
		$12,384
Maintenance and Operation:		
Labor and supervision, 28,200 tons @ 50 cts.	$14,100	
Fuel and supplies	8,000	
Repairs and renewals:		
4% on $3,000	$120	
2% on 60,000	1,200	
10% on 74,000	7,400	
	8,720	
Superintendent, ½ time	1,200	
		$32,020
Total		$44,404

	Per ton.	Per capita.
Fixed charges	$0.439	$0.070
Maintenance and operation	1.135	0.182
Total	$1.574	$0.252

Estimated Cost of Construction for Disposal of Night Soil.

CONSTRUCTION.

First Cost:		
Land	$1,000	
Dumping chamber & sewer connection	4,000	
Engineering and contingencies 10%	500	
Total		$5,500

OPERATING EXPENSES.—1907.

Fixed Charges:		
Interest, 4% on $5,500	$220	
Sinking fund, 20-year, 4% bonds	185	
		$405
Maintenance and Operation:		
Labor and supervision	$700	
Repairs and renewals	250	
Supplies, water, etc.	250	
		$1,200
Total		$1,605

	Per cu. ft.	Per capita.
Fixed charges	$0.0032	$0.002
Operating expenses	0.0093	0.007
Total	$0.0125	$0.009

Summarized Estimates of Construction and Operating Expenses.

CONSTRUCTION.

First Cost:		
For collection of garbage and rubbish	$116,050	
For disposal of garbage and rubbish	168,300	
For disposal of night soil	5,500	
Total		$289,850

OPERATING EXPENSES.—1907.

Fixed Charges:		
Collection of garbage and rubbish:		
Interest	$4,642	
Sinking fund	3,897	
		$8,539
Disposal of garbage and rubbish:		
Interest	$6,732	
Sinking fund	5,652	
		$12,384
Disposal of night soil:		
Interest	$220	
Sinking fund	185	
		$405
Total interest	$11,594	
Total sinking fund	9,734	
Total fixed charges	$21,328	$21,328
Maintenance and Operation:		
Collection of garbage and rubbish	$53,720	
Disposal of garbage and rubbish	32,020	
Disposal of night soil	1,200	
		$86,940
Total cost, collection of garbage and rubbish	$62,259	
Total cost, disposal of garbage and rubbish	44,404	
Total cost, disposal of night soil	1,605	
Total operating expenses	$108,268	$108,268

Operating Expenses Per Capita for Collection and Disposal of Garbage and Rubbish and Disposal of Night Soil in 1907.

	Fixed charges.	Maintenance and operation.	Total.
Collection of garbage & rubbish	$0.049	$0.305	$0.354
Disposal of garbage and rubbish	0.070	0.182	0.252
Total	$0.119	$0.487	$0.606
Disposal of night soil	0.002	0.007	0.009
Grand total	$0.121	$0.494	$0.615

Operating Expenses Per Ton for Collection and Disposal of Garbage and Rubbish in 1907.

	Fixed charges.	Maintenance and operation.	Total.
Collection of garbage & rubbish	$0.303	$1.905	$2.208
Disposal of garbage and rubish	0.439	1.135	1.574
Total	$0.743	$3.040	$3.782

Operating Expenses Per Cubic Foot for Disposal of Night Soil in 1907.

	Fixed charges.	Maintenance and operation.	Total.
Disposal of night soil	$0.0032	$0.0093	$0.0125

The preparation of detailed plans and specifications for the work estimated on was deferred until the work was absolutely decided on and a site provided. It is suggested that a temporary contract be made with the Columbus Sanitary Works Co., to cover the period between April 1, 1906, and the installation of a city plant. Acknowledgment of assistance from Mr. W. W. Jackson is made by Mr. Gregory.

In reviewing and approving Mr. Gregory's report, Mr. Hering stated that in designing garbage furnaces for Columbus provision should be made for operation with and without drying the garbage preliminary to burning, thus making it possible to defer the decision whether fuel should be used to dry the garbage or to burn it. Likewise the decision as to heat utilization, beyond that for works purposes, may be postponed. Heat utilization, if practiced at Columbus, would "be but a secondary consideration," and could not be expected "to reduce the expense otherwise necessary for burning garbage."

A separate collection of garbage and rubbish at Columbus is advisable, because if dumped in the same wagon the rubbish would absorb much water which might be drained off from the garbage alone, before putting the [illegible] on the fires. Moreover, different types of [illegible] can be used advantageously for garbage [illegible] rubbish, and the latter need not be [illegible] so often as the former. It is possible, [illegible] that refuse sorting may prove advisable [illegible] Columbus, if refuse and garbage are collected [illegible] tely.

As to the apparently high cost of [illegible] ge and refuse disposal at Columbus, shown [illegible] e estimates, it must be remembered that [illegible] of the similar work elsewhere is imperfect [illegible] e and is generally less comprehensive than [illegible] d that the data and estimates for Columbus [illegible] re unusually complete.

Mr. Hering suggests that the city [illegible] pare a design for furnaces, "in accordance [illegible] ith the best knowledge and practice," and [illegible] in view of the large and successful experience [illegible] f European cities with the burning of city [illegible] se both American and the more prominent English firms building such furnaces be given an opportunity to submit designs and bids, "as well as bids to supervise the operation for one year, guaranteeing the results to be obtained thereby." In view of the unsuccessful results obtained with many American furnaces heretofore the need for great care in the Columbus designs is apparent. It will also be necessary to employ a high grade of operators when the furnaces are put in use.

NOTES FROM THE ENGINEERING SCHOOLS.

HARVARD UNIVERSITY.—On March 2 the first number of the "Harvard University Gazette" appeared. It contains various announcements regarding coming lectures, appointments to the faculty, and publications by members of the University. A series of six lectures on "Some Applications of Physical Chemistry to Metallurgy" is being delivered by Mr. Woolsey McAlpine Johnson, of New York City. The lectures are open to the public, and it is a pleasure to note that "students of the Massachusetts Institute of Technology are specially invited."

TRINITY COLLEGE, HARTFORD, CONN.—Beginning September, 1906, the college will offer a four-year course in Sanitary Engineering, leading to the B. S. degree. Special work will be taken in the Departments of Natural History, Physiology and Hygiene and Civil Engineering; emphasis being placed upon the relation of health and disease to food and milk supplies, and to the disposal of towns' wastes.

UNIVERSITY OF MICHIGAN.—A chair of architecture has been founded, and Mr. Emil Lorch, A. M., has been appointed Professor of Architecture, to enter upon his duties at the beginning of the next university year. Professor Lorch studied at the Massachusetts Institute of Technology, Harvard University (M. A.), and the Ecole des Beaux Arts, in Paris. Subsequently he spent five years as an architect, part of the time in Boston offices. He has taught architecture at Harvard University and at the Drexel Institute in Philadelphia.

UNIVERSITY OF ILLINOIS.—A liquid air plant has been set up by the Department of Physics. The liquefier is a Hampson apparatus, imported from London. It receives air compressed to 2,500 to 3,000 lbs. The compressor belongs to the Department of Mechanical Engineering, and is a four-cycle machine, made by the Norwalk Iron Works. The capacity of the liquefying plant is about one liter per hour, to produce which about 10 HP. is required. It is said that only two or three other American universities own liquid air plants.

PRESIDENT ROOSEVELT'S CRUSADE AGAINST tuberculosis in government departments at Washington, D. C., has resulted in an order issued by him to the heads of all executive departments to cause to be printed, posted and distributed in every Federal building under their control a set of rules to prevent the spread of tuberculosis. These rules have been formulated by a committee previously appointed by the President. Besides posting and distributing rules each department head must ascertain the names of all persons in his department afflicted by tuberculosis and present every such person with a copy of the rules named. Non-observance of these rules may be made a cause of

dismissal fro[m] government service. The order provides for g[en]t examinations of all persons regarding wh[om] re is a doubt as to whether or not they have [tu]berculosis. The surgeons general of the Army, the and the Public Health and Marine Hospital S[er]vice are directed by the order to cause a thorough [in]spection of the public buildings and worksh[ops] der their respective departments; and are author[ized] detail a sanitary board, or boards, for this pu[r]pose. The inspection of the public buildings and work[s] other than those under the War and Navy Depa[rt]ments shall be conducted under the surgeon gener[al] the public health and Marine Hospital Service. T[he] sanitary board or boards thus appointed shall report [to] (1) Insanitary conditions immediately remediable. Insanitary conditions requiring structural chan[ges] The sanitary board or boards will make reports to the surgeon general of their respective services, who shall bring these reports before the committee appointed by executive order of Dec. 7, 1905, and said committee shall transmit a full report, with recommendations to the President.

PHILADELPHIA FILTRATION CONTRACTS held by Daniel J. McNichol Co. have been annulled by the new Director of Public Works, Mr. Hicks. These include contracts for the Torresdale filters, let Jan. 18, 1902, and July 28, 1904, contracts for preliminary filters at both the Torresdale and the Belmont plant, and contracts for water mains. All these contracts have been suspended since May, 1905. The aggregate of the limit prices for the several contracts is $9,145,000, on which the city has already paid $6,894,830. It is expected that the annulment will be fought in the court. A filter contract held by Henderson & Co. has also been annulled.

THE USE AND WASTE OF WATER at Battle Creek, Mich., and the value of the same (such as is not paid for) at 10 cts. per 1,000 gallons, for the year 1905, is summarized in the last annual report of Mr. W. W. Brigden, Superintendent and Civil Engineer, as follows:

Paid for by meter (12.2 cts. per 1,000 gallons, average)	53	$23,000
Paid for not metered	5	2,200
Parks, public buildings, etc., except schools	8	3,500
Schools, including lawns	6	2,600
Drinking fountains for horses	5	2,200
Flushing sewers	5	200
Blowing off hydrants	.5	200
Wetting down trenches, sewer, water, etc.	2	800
Fires	4.5	2,029
Slip of pumps	3	1,300
Under-registration of meters	6.5	2,800
Leaks	6	2,600
Totals	100	$43,429

The percentage of taps metered in 1905 was 88, or 3,279 out of 3,723. The average daily water consumption and waste per capita was 52 gallons. The meter rates range from 7 to 13 cts. per 1,000 gallons, with a minimum annual rate of $3. All new water takers are required to put on meters, and all who change pipes or fixtures or add thereto.

A NOTEWORTHY CONCRETE ARCH BRIDGE was built recently in Ulm, Wurttemberg, Germany. It is a street crossing over a new switching yard of the State Railways, and is a three-hinged arch, with solid filling. The end hinges are not at the spring of the arch, but are carried on cantilever brackets 14 ft. long projecting from the abutments. The clear span between abutments is 215 ft.; the distance between end hinges is 187 ft., and the rise is one-tenth the latter figure, or 18.7 ft. The hinges are of cast steel. Abutments and arch ring are of plain concrete, with a maximum pressure of 570 lbs. per sq. in. in the arch ring. The roadway structure, however, is of reinforced concrete; it is 33 ft. wide over all, including two 6½-ft. sidewalks. The centering of the arch was carried on sand-boxes, and was slacked by 180 pioneers detailed for the purpose from Battalion 13. The cost of the bridge was 180,000 marks, or about $45,000. Of this, 13% was expended for centering.

HIGHWAY IMPROVEMENTS IN MAINE have not yet advanced far, judging by the first annual report of the State Highway Commissioner, Mr. Paul D. Sargent, of Augusta. According to this report there are in the State 22,000 miles of dirt roads, 2,238 miles of gravel roads, 65 miles of macadam and 22 miles of granite blocks pavement. The average expenditure per mile for maintenance of county roads, during the year covered by the report, was $37.58, one-fourth of which was for making snow roads in winter. There are 552 road machines in use in the State. By a recent act, the State of Maine shares half the expense of permanent improvements on State roads to the extent of not more than $300 to each town. Under an earlier act the State, from 1901 to 1904, inclusive, had paid $72,891 of a total expenditure of $178,370 under a State aid law.

SPECIAL CARS FOR CARRYING AUTOMOBILES are being put in service on the trunk line railways. The New York Central Ry. has cars which can be used either for automobiles or as ordinary baggage cars. These are 60 ft. 10 ins. long and 10 ft. wide, with a total height of 13 ft. 5 ins; the roof is of the round or turtle-back pattern instead of having the usual monitor deck. The Pennsylvania R. R. uses a modification of its standard box cars, 38 ft. long over the end sills, 9 ft. wide over the side sills and 8 ft. 5⅜ ins. high from floor to plate. The Altoona shops are building 100 of these cars.

LOCOMOTIVE BOILERS WITH COMBUSTION CHAMbers are being tried on the Northern Pacific Ry., and with highly satisfactory results in the reduction of boiler repairs and leaky tubes, while the steaming capacity is as good as in similar boilers without the chamber. The heating surface is 3,230 sq. ft. for the tubes and 3,490 sq. ft. in all, the combustion chamber giving 60 sq. ft. The similar boilers without the chamber have 3,818 sq. ft. of heating surface in the tubes, and a total of 4,028 sq. ft. The chamber is 3 ft. long, and approximately oval; it is supported by sling stays, staybolts and bottom brackets, and the width of water space is 6¼ ins. at the sides and 7 ins. at the bottom. The firebox is 8 × 5½ ft. These boilers are in use on tandem compound engines of the 4-6-2 type, and were designed by Mr. D. Van Alstyne, Mechanical Superintendent of the Northern Pacific Ry.

A FRENCH COAL MINE DISASTER on Saturday, March 10, caused the loss of about 1,200 lives. A widespread explosion occurred in the Courrieres collieries, near Lens, Pas de Calais, on the morning of March 10, when about 1,800 miners were at work. Only six or seven hundred of these escaped. A rescuing party of 17 was also lost. It is said that a small outbreak of fire occurred two days before the explosion. A dispatch from the meteorological observatory at Laibach, Austria, states that unusually strong seismographic disturbances were recorded there on Friday and Saturday.

A SUPREME COURT DECISION in the Chicago street railway franchise cases was rendered on March 12. The full opinion has not yet been handed down, but it appears that the principal contentions of the street railway companies in opposition to the proceedings of the city authorities to oust them from certain streets on the ground of expiration of franchise were thrown down. The decision clears the way for a reasonable adjustment of the tangled franchise situation in Chicago.

NEW STEEL UNDERFRAMES for old wooden cars are being applied in repair work for the Hocking Valley Ry. and the Toledo & Ohio Central Ry. The steel underframe has a box-girder center sill formed by a pair of channels and a cover plate, and to the sides of this are attached cantilever brackets supporting the old intermediate sills and side sills. These underframes are built by the Ralston Steel Car Co., of Columbus, O., which has a contract for applying them to over 10,000 freight cars of the railway mentioned above.

SHORT WOODEN COAL CARS of considerable depth are in use on a number of Southern railways, but as a general thing the longer and shallower gondola type of car is preferred. With the high center of gravity of the deep cars, they give considerable trouble on lines having many sharp curves, as they tend to ride hard on the side bearings and so make it difficult for the trucks to swivel when entering and leaving curves.

STEEL CENTERS FOR ERECTING MASONRY arches were used recently in building a large stone arch bridge over the Rhine at Basel, Switzerland. The bridge has six spans, each 80 ft. long in the clear, and of 13-ft. rise. The arch ring is 62 ft. wide. The midstream pier is an abutment pier, so that either half of the bridge is able to stand without the other. This was convenient in erection, as it made it possible to erect the bridge in six sections, each covering three spans and a width of one-third the ring. The centering required was therefore only so much as corresponds to one full span. The centering consisted of steel bowstring trusses, whose top chord followed the ortline of the intrados of the arch as closely as might be. Transverse timbers resting on the top chords of the trusses and placed rather close together were blocked to such heights as to give the exact curve of the arch; longitudinal lagging strips over these timbers formed the face of the centering. The trusses, four in each arch (12 trusses in all), carried their loads directly to the piers, by means of a shoe under each end of each truss, which rested on a projecting course of the pier. Screw-jacks were set under the shoes for adjusting the centers to proper level and for slacking the centers. The four trusses in each span were braced together in pairs by fixed sway-frames at the panel-points, and the two pairs were braced together by removable portals. Each pair of trusses, therefore, was a unit in shifting longitudinally, but for transverse shifting when changing the centers from one section to another in the same span, all four trusses were shifted simultaneously. The first section erected was an outer third of the three arches of one half; when this was set, the centers were slacked and shifted across the arch to the opposite side of the same three spans, and lastly the middle third was placed, after which the other three spans were erected in the same order. The rigidity of the steel centering, and the use of screw-jack supports, made it possible, when placing the middle section between the finished outer sections, to adjust the centers almost absolutely to the height of the side sections. In erecting each one of the six sections of the work the arch-stones were put in place dry, i. e., without mortar, but with wedges in the joints, continuously from skewbacks to crown; then all the joints were grouted simultaneously with a thin 1:2 Portland cement mortar. After this the section was left to set for two to four weeks before slacking centers. The drop of crown when slacking centers varied from 4 to 10 mm. and averaged 7 mm. (¼-in.) for the outer rings of the six spans. The backs of the arch-rings are waterproofed with asphalted felt, covered with 2 ins. of concrete for mechanical protection. The filling over the arch-rings to carry the roadway paving was made of a very lean concrete (1 part hydraulic lime to 20 parts sand and gravel) with a view to avoiding subsequent settlement. The bridge was completed in October, 1905.

THE FUEL COST per KW.-hour of output in several large English electric power stations is as follows, according to the London "Times:" Glasgow Tramways, 0.30 ct.; Newcastle Supply and Newcastle Tramways, each 0.32 ct.; Leeds Tramways, 0.38 ct.; Sheffield Tramways, 0.40 ct.

A $2,000,000 BOND ISSUE for a sea wall at San Francisco, authorized at a popular election in November, 1904, has been declared legal by the California State Supreme Court. It is stated that the bonds will at once be placed upon the market by the State Board of Harbor Commissions, of which Charles H. Spear is President.

A GOLD AND SILVER MEDAL have been offered by the "Public Health Engineer," of London, for the best essays on the Dust Problem. The competition is open to writers in all parts of the world. The papers, under a nom de plume, must reach the journal named (50 Ludgate Hill, London, E. C.) by April 28, 1906. No names of competitors will be published except those who win the prizes. All papers or parts of papers printed by the journal named will be paid for at its usual rates.

THE SALE OF GAS FITTINGS by the Municipal Gas Department of Birmingham, England, has recently been objected to by the Master Gas Fitters' Association, of that city. In replying to this objection, the secretary of the gas committee stated that the committee could not stop the sale of fittings, because (1) the fittings business forms an important asset of the gas undertaking purchased by the city in 1876, and it was considered "impossible to hand over to a section of the ratepayers a property purchased by the whole municipality;" (2) and because the committee considered the fittings business of the department "necessary to the convenience of customers, and essential to the development of the undertaking." The committee also stated that "the annual turnover" in the fittings branch has declined from £24,271 in 1901 to £21,839 in 1905, having slightly exceeded the former figure in 1903. From these figures the committee thought it apparent that the loss of business claimed by the Gas Fitters' Association must be due to other causes than the business carried on by the City Gas Department, as among these causes it was stated that there had been an increase in the number of Master Gas Fitters from 75 in 1885 to 96 in 1905. The committee also stated that it did not advertise nor canvas for trade, nor bid for work unless requested; and that it charged an adequate profit on both materials and labor (not less than 25%) and paid the "full standard rate of wages for" all the labor employed.

ASYNCHRONOUS GENERATORS ON AN ELECTRIC transmission line are used in a Swiss electric power system for the purpose of simplifying the regulation of the system. Power generated at three different water-power stations is fed into a common transmission line about 35 miles in total length. To make it possible to regulate the voltage from one station, and avoid the necessity of synchronizing generators when throwing them on the line, two of the stations are equipped with asynchronous generators (that is induction motors run at a speed above synchronism, when they become generators), while the other station, which is the central station, has the usual type of synchronous generator. This latter, then, fixes the voltage and the frequency of the system; the other two stations, as soon as their machines are thrown on the line, automatically assume the frequency and voltage of the system, and deliver to it the full power of their turbines. All load-variations are taken by the machines of the main station. When the load on the system becomes less than the output of the two asynchronous stations, the synchronous generator speeds up, which is the signal for cutting out one of the synchronous stations. These two stations require only one attendant each. The rotors

of the asynchronous machines are squirrel-cage armatures without insulation. They require no exciters, and their switchboards carry only instruments and a circuit-breaker. The plant was equipped by the Oerlikon Works. It has been in operation since January, 1906, and has hitherto given full satisfaction.

A NARROW-GAGE SINGLE-PHASE RAILWAY is being built between Locarno, Pontebrolla, and Bignasco, in southern Switzerland. It is of 1-m. (3.28 ft.) gage, and has grades as high as 3.3%. The motive-power will consist of eight-wheeled motor cars, each equipped with four 40 HP. single-phase motors, hauling passenger and freight trailers in trains of 60 tons maximum weight. The trolley current will be at 5,000 volts pressure, and the cars will take current by a lateral collector arm. The road will be the second single-phase railway in Switzerland, and will be equipped by the Oerlikon Works, who also equipped the Seebach-Wettingen single-phase railway (15,000-volt).

PERSONALS.

Mr. H. S. Hancock, of Winnipeg, Man., has been appointed Town Engineer of Fort William, Ontario.

Mr. Carl Scholz has been appointed Mining Engineer of the Chicago & Eastern Illinois R. R., with headquarters at Chicago.

Major Charles H. McKinstry, Engineer Corps, U. S. A., has been temporarily assigned to duty as Chief Engineer of the Pacific Division.

Mr. A. M. Bouillon, Engineer in the Reclamation Service, at Huntley, Mont., and Miss Helen Evangeline Godman, of Denver, Colo., were married recently in Denver.

Mr. Clinton S. Thompson has been appointed as Topographic Draftsman in the Reclamation Service and ordered to report to Mr. John S. Field, District Engineer, at Mitchell, Neb.

Mr. C. E. Slonaker, Observer, and Mr. Ernest E. Childs, Assistant Engineer, of the Reclamation Service, have been transferred to Portland, Ore., where they will report for field duty.

Mr. Albert O. Smith, Jun. Am. Soc. C. E., has opened an office at Greenpoint, N. Y., where he will practice his profession as a civil engineer. Mr. Smith was graduated from the University of Vermont in 1902.

Mr. Horace E. Andrews, President of the Cleveland Electric Railway Co., Cleveland, O., has sailed for Europe. He will tour in an automobile, inspecting local street car lines and interurban railway systems.

Mr. George C. Chaney, Assistant City Engineer, of Salt Lake City, Utah, has been appointed Chief Engineer of Water-Works and will have charge of the engineering in connection with the Big Cottonwood conduit project.

Mr. W. H. Prentice, Assistant Chief Engineer of the Missouri, Oklahoma & Gulf Ry., at Muskogee, Ind. T., has been appointed Superintendent, temporarily, to fill the position made vacant by the resignation of Mr. O. M. Sewell.

Mr. Robert H. Dwyer, formerly Superintendent of the Colorado Division of the Missouri Pacific Ry. System, has been appointed General Manager of the Denver, Laramie & Northwestern R. R. Co., with headquarters at Denver, Colo.

Mr. W. S. Hanna, Engineering Aid, in the Reclamation Service, has been transferrd from the Washington office, where he has been employed in the drafting division, to field duty at Chinook, Mont., in connection with the Milk River Project.

Mr. Paul G. Brown, formerly Assistant City Engineer of Chicago, and more recently General Superintendent with the Degnon Contracting Co., New York, has resigned this position to become Manager of the United Engineering & Contracting Co., 32 East 33d St., New York City.

Mr. Carrol Paul, Engineering Aid, in the Reclamation Service, who has been on furlough on account of lack of work, due to climatic conditions, has been reassigned to duty and ordered to report to Wyncote, Wyo., for work in connection with the Interstate Canal Project.

The Mexican Pacific Railway Co. having acquired the property of the Mexican National Construction Co. in the State of Colima, Republic of Mexico, Mr. A. P. Herbert has been appointed Superintendent in charge of operation of the constructed line between Colima and Manzanillo, with headquarters at Colima, Colo.

Mr. Frank Galennie, Jr., of St. Louis, Mo., who invented an electrical device some years ago which, it was claimed, reproduced the human voice by means of electric lamps, is ill at Eureka Springs, Ark., recuperating from tuberculosis of the arm. He was at one time connected with the Kinloch Telephone Co., of St. Louis.

Mr. J. T. Taffany, Division Engineer of the Jefferson and Wyoming Divisions of the Erie R. R., has been transferred to the New York Division, to succeed Mr. S. C. Brown, resigned, to go in business in New York City. Mr. Trimble, formerly Assistant Division Engineer of the Mahoning Division at Youngstown, O., will succeed Mr. Taffany at Dunmore, Pa.

Mr. William J. Welch has recently been appointed as Water Commissioner of Boston, Mass. Mr. Welch has been associated with the Water Department for nearly 20 years, entering as Superintendent of the Mystic Division in 1888. Since that time he has acted as Assistant Superintendent and Superintendent of the Water Department, which latter position he relinquished to become Water Commissioner.

The Department of Water Supply, Gas and Electricity, of the city of New York, has made the following appointments of engineers: Alfred D. Finn and Robert Ridgeway, of New York, as department engineers, at $6,000 a year each; Thomas H. Wiggin, of Pittsburg, Pa., as designing engineer, at $4,000 a year; Carleton E. Davis, of Brown Station, N. Y., as department engineer, at $6,000 a year; John D. Groves, of Syracuse, N. Y.; Ralph W. Greenlaw, Frederick Ward, Leonard P. Wood and Arthur V. Ruggles, of New York, to be assistant engineers, at salaries ranging from $1,650 to $2,000 a year.

Mr. Dana Pierce has been engaged by the Underwriters' Laboratories, under the direction of the National Board of Fire Underwriters, Chicago, as Engineer-in-Charge of electrical work. Mr. Pierce was graduated from Amherst College with the class of 1892, and since that time has devoted himself to physical laboratory practice and electrical engineering, taking a post graduate course at Johns Hopkins University. He afterwards practised at the laboratories at Harvard and Cornell Universities; also conducting experiments in high tension electrical measurements at Worcester Polytechnic Institute and acting as instructor in laboratory work at Pratt Institute.

The following changes have been made in the Reclamation Service: Mr. S. D. Baker, Assistant Engineer, transferred from Berkeley, Cal., and assigned to duty under Mr. J. Ahern, on the Shoshone Project, Wyo. Mr. Geo. H. Bliss, Engineer, assigned to duty in the technical section, Washington office, because of the delay in starting work on the Lower Yellowstone Project, Mont. Mr. Ferdinand Bonstedt, Engineer, has been assigned to duty on the Okanogan Project, Wash. Mr. W. H. Fisher, Engineering Aid, has been assigned to duty on the Shoshone Project, Wyo. Mr. Philip W. Price, Assistant Engineer, has been assigned to duty on the Okanogan Project, Wash. Mr. Joseph A. Sargent, Engineer, formerly employed on the Uncompahgre Valley Project, Colo., has resigned from the service. Mr. Harold S. Williams, Assistant Engineer, will be transferred from work in Washington, under Mr. D. C. Henny, for duty under Mr. D. W. Ross, on the Minodoka Project, Idaho. Mr. J. E. Shoemaker, Engineering Aid, now employed at the testing laboratory at St. Louis, Mo., will be transferred to duty on the Huntley Project, Mont., as soon as his successor is appointed.

Mr. E. J. Beard, M. Am. Soc. C. E., whose resignation as Principal Assistant Engineer of the Chicago, Rock Island & Pacific Ry. was noted last week, is a railroad engineer of many years' experience. Mr. Beard will go to New York shortly to collaborate with the New York headquarters staff engineers of J. G. White & Co. in drawing up preliminary plans for the railroad incursion in the Philippines. He will sail later for the scene of operations and it is expected that this big enterprise will be put under full way during the coming summer. Under the contract recently awarded by the Insular Government, the White Syndicate will build and equip over 300 miles of steam railroad, roughly divided in thirds, among the principal islands of the Viscayan Group, Negros, Cebu and Panay. This contract includes operating prerogatives for a period of 30 years to become optional thereafter and is valued at $11,000,000. Mr. Beard will have for his chief adviser Mr. L. E. Bennett, who has made the reconnoissance survey of the ground in the Philippine Islands. Mr. Beard was at one time a contracting engineer and built the Street and Suburban Railway, of Meridan, Miss., in 1890. Thereafter he became Superintendent and Engineer of the New Orleans & Northwestern Railroad. In 1894 he went to the Kansas City, Pittsburg & Gulf Railroad, on which he served successively as Location Engineer, Division Engineer, and Assistant Chief Engineer. In 1895 and 1896, Mr. Beard acted as Superintendent and Chief Engineer of the Gila Valley, Globe & Northern Railroad, of Arizona, and in 1897 became associated with the Boston & Montana Copper Co. as Chief Locating Engineer for the railroads of that company in New Mexico and Arizona.

Obituary.

M. P. Mason, President of the Mason-Hoge Co., one of the most widely known railroad contractors in the country, died at his country home at Frankfort, Ky., on March 7.

James H. Forsyth, Chief Clerk of the Surveyor's Office, District of Columbia, died of paralysis on March 4 at his residence, 1802 Belmont Ave., Washington. He had been employed in the office of the District Surveyor for 40 years.

Harvey Beckwith, a mining expert, died at his home, 1822 North Park Ave., Philadelphia, from injuries received by a recent fall in his room. He was born in Northfield, Mass., 77 years ago. He was one of the settlers of Virginia City, Nev., and for many years took an active interest in the affairs of that city. Mr. Beckwith is survived by a widow.

Charles Geissert, a former commissioner of highways in Philadelphia, died on March 2 at the home of his son-in-law, Christian Fraser, 2001 North Broad Ave., Philadelphia. He was born in that city in 1824. Governor Packer, in 1860, put him in charge of the railroad then operated between that city and Columbia, which later became the property of the Pennsylvania Railroad Co.

William Winslow Ames died on March 7 at Montclair, N. J., after a prolonged illness. He was a civil engineer and was at the head of the Montclair Light & Power Co. before it was absorbed by the Public Service Corporation. He did some of the electric wiring work on the Brooklyn Bridge. He was about 45 years of age and was the son of the late James H. Ames. He is survived by a widow.

George Jacob Burnap, Captain, a retired Chief Engineer in the United States Navy, died at his home in Philadelphia on March 7. Captain Burnap entered the service in 1861 as Assistant Engineer. During the Civil War he served on the U. S. S. "Roanoke," "Comerone," "Susquehanna," "Aristook," "Kansas," and "Quaker City." He was commissioned First Assistant Engineer on July 25, 1866, and Chief Engineer on November 1, 1879. He was transferred to the retired list on Feb. 10, 1899.

John W. Babson, Chief of the issue and gazette division of the United States Patent Office, died at his home in Washington on March 1, aged 71 years. He was born in Maine and was graduated from Maine Wesleyan College, where he afterward served as an instructor. He went to Washington in 1861 as Secretary to the then Vice-President, Hannibal Hamlin, and in 1896 was transferred to the Patent Office. He served as Departmentary Commissioner of Patents, Chief of the Pension Division, and in charge of the official gazette, which was under his supervision up to the date of his death.

William N. Gibson, C. E., died recently at Uncia, Bolivia, S. A., after a few days' illness, of pneumonia. He was born near Pittsburg, Pa., and was graduated from the Civil Engineering Department of the Western University of Pennsylvania at Allegheny in 1902. He entered the Engineering Department of the Baltimore & Ohio R. R. and was engaged on work in and near Pittsburg until July, 1905, when he resigned to accept a position as Assistant Resident Engineer with the Bolivian National Railways. On January 15 he was promoted to the position of Assistant Engineer and placed in charge of Field Corps No. 3 to make a survey for a line from Oruro to Potosi via Uncia, at which he was engaged at the time of his death.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 20-22. Annual meeting at Chicago, Ill. Secy., L. C. Fritch, 1502 Monadnock Block, Chicago, Ill.

AMERICAN RAILWAY ASSOCIATION.
April 25. Semi-annual meeting at Chicago, Ill. Secy., W. F. Allen, 24 Park Place, New York City.

AMERICAN ELECTRO-CHEMICAL SOCIETY.
May 1 to 3. Annual meeting at Ithaca, N. Y. Secy., S. S. Sadtler, 39 South 10th St., Philadelphia, Pa.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May 1 to 4. Semi-annual meeting at Chattanooga, Tenn. Secy., F. R. Hutton, 12 West 31st St., New York City.

ENGINEERS' CLUB OF PHILADELPHIA.—At the next meeting of the club, March 17, Mr. H. W. Latta will read a paper entitled "The New Sea Wall at the Naval Academy, Annapolis, Md." The paper will be illustrated with lantern views.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The March meeting is to be held at the Edison Auditorium, 44 West 27th St., New York, at 8.15 p. m., March 23. Two papers will be read and discussed: "Some Features Affecting the Parallel Operation of Synchronous Motor-Generator Sets," by J. B. Taylor (General Electric Co.), and "Notes on the Design of Hydro-Electric Power Stations," by D. B. Rushmore (General Electric Co.).

WESTERN SOCIETY OF ENGINEERS.—At the meeting on March 7, held at the Society's rooms in Chicago, Prof. E. G. Smith, of Beloit, Wis., presented a paper on "Urban Tendencies of Population as Affecting the Problems of the Engineer." He showed that the growth of population is relatively greater in towns of moderate size than in the large cities, and briefly discussed various phases of the subject, but devoted his attention principally to the questions of water supply and sewerage disposal. In the discussion Mr. McMeen referred to studies he had made in connection with the growth of population in certain districts of a city and the most economical location of telephone exchanges with a view to this growth.

ENGINEERING LITERATURE

Supplement to ENGINEERING NEWS. New York, March 15, 1906.

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The hydro-electric plants of the United States, Canada and Mexico are to be described in a two or three volume work now being prepared by Mr. Arthur W. Clapp, Monadnock Block, Chicago. The author desires information that will enable him to describe all plants of over 500 HP. capacity, of which he estimates there are 350 in the three countries named. He proposes to devote 3,000 to 5,000 words to each plant. Most of the information is being secured from the operating or designing or constructing engineers, to whom the published work will be supplied without charge.

CORRESPONDENCE.

The Make-Up of Godfrey's Structural Engineering Tables.

Sir: Permit me space to defend the arrangement of tables and order of pages in my book of "Structural Engineering Tables," noticed in your issue of Feb. 14, 1906. Your reviewer stated "that appearance and ease of reference are seriously affected on account of diversified type and arrangement of tables and because of lack of order of the contents." Taking up the tables themselves, I do not see how the variety of type can interfere with their usefulness, so it must be to the way the tables are turned that your criticism refers, some being read with the book upright and others with the edge facing the user. In this connection you called attention, not very long ago, in reviewing another book of tables, to the fact that lack of register made some split tables hard to use. It is difficult to follow a line of figures across from one page to the next, even if they are just opposite, or registered correctly. Some of the tables are too broad for a page, placed vertically, and I for one, as an inveterate user of tables, would prefer to turn the book and read the table the other way rather than to follow a line of figures across two pages or to have the type small. I have yet to hear of any good reason why a table is not just as serviceable and as easily read when placed one way as another. In one instance, namely, in the weights and areas of flat plates, I placed the areas "up and down" and gave areas only to 1¼-in. thickness. I have found in using these tables that frequently I will take the area in place of the weight, as both tables look alike, as usually given. Thicknesses more than an inch or so are seldom needed in the area table.

Now as to the order of the pages. This book was made for Use with a capital U, and not for a course in "Tables." If they do not follow the order in which the various subjects might be developed in a text book, it is because this consideration did not enter in their arrangement. There are three places most easily found in a book, namely, the middle and the beginning and the end. We all know, or ought to know, how easy it is to find the Psalms, or Genesis, or Revelation in our Bibles; but some of us might be puzzled if asked to locate Nehemiah offhand. The first few pages of my book are devoted to tables very often used, such as decimals of an inch or foot (which I failed to make clear to a contemporary reviewer I did not mean to claim as original), rivet values, weights and areas of angles, etc. The end of the book is devoted to tables of squares, roots, etc., also very much used. The middle contains properties of built sections, all placed together, for quick reference for the designer. The middle is flanked on one side by drawings and on the other by tables of formulas, etc. All tables concerning details, such as clevises, nuts, separators, etc., are bunched together, as also those concerning the calculations performed by a draftsman.

If your reviewer can suggest a better order in which to place these tables, I should like to know what it is. I have often wished that the oft-needed tables in certain books had been placed in easily located parts of the book, instead of having these parts filled with pictures and other matter seldom needed.

Yours very respectfully,

Edward Godfrey.

Monongahela Bank Bldg., Pittsburg, Pa., Feb. 21, 1906.

[We fully recognize the necessity, in some instances, and the desirability, in others, of running tables up and down the pages. That the reviewer of the book in question is not alone in his opinions as to the arrangement of the tables, is shown by two sentences which we take from a letter received since the foregoing communication was put in type:

I wish to thank you most heartily for your discriminating review of Godfrey's Tables. It was very appropriate to use this occasion to call special attention to the lack of care or judgment in the selection of type for use in that book.

—Ed.]

Donkin's Gas Engines Revised.

Reviewed by Storm Bull.*

A TEXT-BOOK ON GAS, OIL AND AIR ENGINES.—By Bryan Donkin, M. Inst. C. E., M. Inst. M. E., M. Am. Soc. C. E., etc. Fourth Edition, Revised and Enlarged. London, Eng.: Charles Griffin & Co., Ltd. Philadelphia: J. B. Lippincott Co. Cloth; 6 × 9 ins.; pp. 568; 165 figures in the text. $7.50 net.

The fourth edition of the late Mr. Bryan Donkin's book has been edited by his private secretary. It was always a good book and all that has been attempted in this new edition has been to bring it up to date. This attempt has been fully realized, and the reviewer does not know of any book in the English language in which so much information can be found about the modern gas engine as in this. As the title implies, the book also treats of oil and air engines. Under oil engines the author includes all gasoline engines, besides the engines using kerosene for fuel; and all these are discussed in the second part of the book, which comprises 256 pages; whereas gas engines proper are considered in the first part, covering 348 pages. Judging from these numbers, it would seem that the treatment of the oil engines is very much fuller than that of the gas engines, if it be remembered how much more important the latter is than the former. But evidently the division between the two classes of engines has not been made very sharp, as, for instance, there is a separate chapter in the second part treating of American gas and oil engines, in which the only treatment of these engines in the whole book is found; this, with the exception of the Westinghouse gas engine, which is discussed under the head of English gas engines, being manufactured in Great Britain by the English Westinghouse company. It is, of course, true that most of the American manufacturers of gas engines also make gasoline engines, but it would seem that the importance of the gas engine industry in this country at the present time would have warranted a separate chapter under the head of gas engines, just as the English, French and German gas engines were given one chapter each. In another respect the American gas engines are treated as step-children in this book, and that is with respect to illustrations. Besides the illustrations of the Westinghouse engines, which are very good, but which, as already stated, are found under the head of English engines, there is only one illustration of American practice—a picture of an Otto four-cylinder engine for a Holland submarine boat. There cannot be any doubt but that the book would have been improved if some more illustrations of American gas engines had been included. The shortcoming in this respect is, however, one which is common to most English books, and to which we gradually have become accustomed.

A large part of the book is taken up by detailed descriptions of all the important engines made in the various countries of the globe. Here will also be found information as to the various sizes made by each manufacturer, the number of engines built and their aggregate horse-power. If the information be correct, which the reviewer has no reason to doubt, it represents a very large amount of labor spent in collecting the data, and it is highly interesting. The historical information about these various manufacturers is also very interesting, and is not found in such an available form in any other publication.

Chapters X. and XI. treat of gas production for motive power; Chapter XII. of the utilization of blast-furnace and coke-oven gases for power; Chapter XIV. of the chemical composition of gas in an engine cylinder; Chapter XV. of the utilization of heat in a gas engine, and Chapter XVI. of the explosion and combustion in a gas engine. These are all very good and very clearly written, and give a very large amount of information. One criticism might be made, perhaps, and that is that the author is somewhat too impersonal. In several places where controverted points are discussed—for instance, the question of after-burning—he gives the contradictory opinions of various authorities without expressing his own, leaving it to the reader to weigh the evidence and make his own conclusions.

Perhaps the least satisfactory part of the book to the reviewer is the one in which the theory of the gas engine is discussed; there is not enough of it, and it would seem that in a book of this size room should be found for the derivation of the formula for the efficiencies of the various gas engine cycles. This is not done, the author simply referring to Dugald Clerk or Witz.

The three chapters on the history of the gas engine are excellent, the descriptions and illustrations being equally good. In other parts of the book the intensely rapid development in the last eight or ten years is vividly brought before one's mind, and the future possibilities are equally brought out.

The third part of the book, treating of air engines, contains hardly anything but historical matter, but is interesting on that account.

At the end of the book will be found a large number of tables containing the results of a great many tests of a variety of gas engines. These seem to have been selected with a good deal of care, and should be useful to all gas engine builders and students of the gas engine.

The title of the book is: "A Text-Book of the Gas Engine." As a teacher, the reviewer can hardly understand how the volume could be used as a text-book; it is certainly nothing but a reference book, although a very good one.

The printing and paper of the book are very good; in general, the illustrations are also good although the reviewer would have preferred to have more real drawings of gas engines and fewer "pictures."

*Professor of Steam Engineering, University of Wisconsin, Madison, Wis.

Electrical Books.

Reviewed by Henry H. Norris.*

ELEMENTARY ELECTRICAL CALCULATIONS.—A Book Suitable for the Use of First and Second Year Students of Electrical Engineering. By W. H. N. James, A. I. E. E., Lecturer and Demonstrator in the Electrical Engineering Department of the Municipal School of Technology, Manchester, and D. L. Sands, Demonstrator and Assistant Lecturer in the Electrical Engineering Department of the Municipal School of Technology, Manchester. London, New York and Bombay: Longmans, Green & Co. Cloth; 5 × 7½ ins.; pp. 216; 52 figures in the text. $1.25.

ELECTRIC WIRING, DIAGRAMS AND SWITCHBOARDS.—By Newton Harrison, E. E., Instructor of Electrical Engineering in the Newark Technical School. New York: The Norman W. Henley Publishing Co. Cloth; 5 × 7¼ ins.; pp. 272; 105 figures in the text. $1.50.

The title of this small book, by Messrs. James and Sands, indicates its purpose clearly. The authors emphasize the necessity for the development of practical working knowledge on the part of the students. In this they are absolutely correct, for, as all teachers know, there is very little mental development to be expected from attendance upon a lecture course. Even if the lectures are accompanied by interesting practical demonstrations, they produce only a temporary impression on the minds of the hearers. This being the case, the most important part of a course of study in electrical engineering is a series of practical problems illustrating the fundamental laws of the electric circuit.

In this book the authors have arranged logically and systematically a series of 362 problems, divided into nine sections or chapters. They are very simple in character, involving only such knowledge of arithmetic and elementary algebra as would be possessed by a high school graduate in this country. They are adapted, therefore, to the first and second years of a college course, or they may be easily solved by persons not in college who have had a fair high school training. While the problems are elementary, they are of a practical nature, in some cases dealing with transmission and distribution circuits in such a way as to stimulate the student by showing him the application of the more fundamental laws. The book may, therefore, be classed as an advanced text-book of electricity in physics, or an elementary one in electrical engineering. The material is such as is usually covered in second year physics in technical schools in the United States.

The treatment begins with a restatement of the primary facts upon which mechanical and electrical laws are founded. Such quantities as length, mass, time, velocity, work, power, current and electro-motive force are described and the fundamental and derived units are defined concisely and clearly. Then follow collections of problems illustrating the use of these units and impressing upon the mind of the person solving the examples the uses of the units in applying the laws which show the relations of the quantities defined. The problems lead up logically to a knowledge of the laws of electric power transmission and distribution. The last two chapters deal with electro-chemistry and photometry, both of which are important topics to be associated with that of the electric current, as a considerable proportion of the amount of electrical energy developed in practice is utilized in the production of chemical compounds and in the reduction of metals, while electric lighting also calls for the production of a large amount of electric energy.

The book is more than a mere collection of problems, for each chapter opens with a brief statement of the laws which are to be illustrated. The student, therefore, begins with a general idea of the theory which is checked and illustrated by the following problems. He can judge of the accuracy of his work by comparing the results with the answers given at the end of the book, where they are arranged for convenient reference. The book contains no index, but has a brief table of contents, giving the list of chapters. In general purpose and arrangement it is similar to "Electric Problems," by Hooper and Wells, but is more elementary than the latter, having no problems on the performance of electrical machinery. It is also similar to "Problems and Questions in Physics," by Matthews and Shearer, but is less complete, in that it deals with fewer topics and is much more elementary.

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The greater part of the electric wiring installed for the distribution of power and lighting current is the work of men who are not familiar with the theory of such distribution. They place conduits, draw in wires and make connections as they have seen these operations performed elsewhere. Even many of the persons who decide on the sizes of wire, style of insulation and other important details do so without adequate reasons for their selections. Wiring seems such a simple operation that many incompetent persons have taken up this line of work without proper preparation. The result has been a large amount of unsafe and unsatisfactory wiring, which is, however, being rapidly replaced by more modern construction. Through the efforts of the associations of fire insurance underwriters and of the trades unions, incompetent workmen have been to some extent eliminated. On the other hand, the business now attracts technically trained engineers, who are prepared to plan wiring installations without neglecting any of the elements of the problem. The men who are doing the actual work also desire to ascertain things in a certain way, and this helpful curiosity has tended toward better work.

Mr. Harrison's book is intended to assist practical wiremen to do a better grade of work by informing them of the reasons for what they do. It is obviously impossible to give in a book of this kind, or, in fact, in any book, an adequate treatment of the subject, for such involves the theory of all kinds of electric machinery and circuits. The author properly makes no such attempt, but devotes his attention to statements of the practical matters connected with the installation of electric machines, including the necessary switchboards and the wiring connecting these with the supply circuits. The discussions can be followed only by those who are familiar with the devices and apparatus discussed, and even with this practical knowledge the statements and diagrams will require careful study. The discussion is non-mathematical, a very elementary knowledge of arithmetic only being necessary on the part of the reader. He must, however, have the ability to associate conventional diagrams with the actual apparatus in order to derive the maximum benefit from the book.

As is customary and proper in such works, the author begins with a concise statement of the elementary laws underlying the art of electric wiring. This is done as well as possible, considering that the writer presupposes no theoretical knowledge of the subject. All of the statements are illustrated with numerical problems, fully worked out and giving practice in the use of the usual wiring tables. The different methods of distributing current are illustrated both by diagrams and numerical examples. This involves the application of Ohm's law, which states the relation of current, electro-motive force and resistance in an electric circuit. Some practical features of electric motor and generator connections are also given, including brief statements of the principles of operation of such machines. The latter are necessarily very elementary and general in nature. Some space is devoted to the subject of insulation, and various methods used for installing wires are described and illustrated. Due reference is made to the rules of the insurance associations relating to the proper installation of wiring and switchboards.

Several chapters are devoted to diagrams of switchboards for different kinds of service. These include dynamo and motor switchboards and distributing panels. The principles of switchboard construction are given concisely, and in connection with this subject such details as lightning arrestors and the testing of circuits are briefly treated.

In the last few chapters the author attempts the difficult task of giving such principles of alternating current circuits as apply to the subject in hand. This section will probably discourage the average reader, for it covers a subject which highly trained technical students find difficulty in comprehending. The author a[dmits] that the treatment would not be c[omplete] out some reference to this impo[rtant] Even if the reader does not co[mprehend] theory as here given, he will ha[ve] great deal of practical and usefu[l] In the opinion of the reviewer, th[is] be better without the last two cha[pters]

The book has a very complete [index] clearly printed and the diagrams [are] It should be useful not only to arti[sans] to architects, builders and others [who] sponsible for the proper installati[on] circuits. It would be a good tex[t] trade school or institute, but it is no[t] use in a technical school.

THE RAILWAY SIGNAL ASSOCIATION.—Proceedings of the Meetings Held in the Year 19[05], Constitution, By-laws, List of Members, etc. New York: The Association (335 Madison Ave.). Paper; 6 × 9 ins.; pp. 360; folding and other plates and text figures.

Among the subjects treated are storage batteries for signal work, "Signaling [for] the New York Subway," by J. M. Waldron, and "Cost of Stopping Trains, Compared with the Cost of Interlocking Plants," by J. A. Peabody.

THE BIOGRAPHICAL DIRECTORY OF THE RAILWAY OFFICIALS OF AMERICA.—Edition of 1906. Edited and Compiled by T. Addison Richey, Associate Editor the "Railway Age." Chicago, Ill.: Railway Age Co. Cloth; 6 × 9 ins.; pp. 694. $3.

This indispensable biographical directory now includes nearly 5,000 names, as compared with 3,764 when the first of the series of six issues appeared in June, 1885. There are some 1,200 new sketches in this edition. A convenient feature of the directory, as compared with all others of this class which we remember, is the use of two paragraphs for each sketch, the first one giving the name, official position and address of the man and the second giving the date and place of his birth, his education, and a chronological record of his railway service.

DUTY OF WATER.—By B. P. Fleming. Bulletin No. 67, August, 1905, Wyoming Agricultural Experiment Station, University of Wyoming (Sent free upon request; address Director Experiment Station, Laramie, Wyo.) Paper; 6 × 8¾ ins.; pp. 20.

The tabular portion of this bulletin shows for various crops the depth of water supplied, by irrigation, rainfall and total, the yield in pounds per acre-foot of water, and the duty in acres per cubic feet per second of water. Some of the records are for the eleven consecutive years, 1893 to 1903, inclusive, and all of them, as we understand it, are the results of observations on Experiment Station land.

LABOR CONDITIONS IN PORTO RICO.—[Part of] Bulletin of the Bureau of Labor, No. 61, November, 1905. Washington, D. C.: Pub. Doc. Paper; 5¾ × 9 ins.; pp. 723-856; tables.

The general character, condition and habits of laborers, their foods and the cost of them are discussed and other information given in text and tabular form. Detailed tables are also given, showing by occupations, and by positions in the several occupations, the sex and nationality of wage earners, days per week, hour per day and per week, and wages per day.

TRANSPORTATION ROUTES AND SYSTEMS OF THE WORLD.—Development of Steam-Carrying Power on Land and Sea, 1800 to 1905. (From the Monthly Summary of Commerce and Finance for November, 1905.) Bureau of Statistics, Department of Commerce and Labor. O. P. Austin, Chief of Bureau. Washington, D. C.: Pub. Doc. Paper; 9¼ × 11½ ins.; pp. 1,549-1,559; tables, and one large folding map.

Few government publications, especially in anything like such a small compass, are as interesting as this one. The map "is intended to present a bird's-eye view of the great land and water transportation routes of the world." The tables contain statistics, some for long series of years, of the growth and present status of transportation facilities by land and water and to some extent, by countries. Some freight rates are also given.

Reinforced Concrete Handbook.

Reviewed by Arthur N. Talbot.*

A HANDBOOK ON REINFORCED CONCRETE.—For Architects, Engineers and Contractors. By F. D. Warren. New York: D. Van Nostrand Company. Cloth: 4½ × 7½ ins.; pp. 271; tables, 34 figures and diagrams. $2.50, net.

This book is prepared as a reference handbook and is intended to be particularly adapted to the wants of architects, engineers and contractors. Part I. contains 23 pages devoted to introductory matter with some references to provisions for securing good construction. Part II. (37 pages) describes and discusses a few tests on beams, floors and roofs, which the author states in the preface justify the use of various constants and coefficients used in the tables. Part III. (118 pages) contains 16 tables in handbook form, giving various properties of specified forms of reinforced concrete beams, floors and columns: safe bending moment, safe load, amount of steel, position of neutral axis, weight of beam per lineal foot, and deflection of floor caused by loading, and also giving comparative costs of reinforced concrete, cast iron, steel and wood construction. The author hopes that the designer may obtain in these tables all necessary information to meet the more common cases in practice. Part IV. (78 pages) contains 16 tables giving properties for roof trusses up to a span of 100 ft., together with 16 diagrams showing the relation of cost to span.

The typographical appearance of this book is so pleasing and the title so attractive that one feels a shock of disappointment at finding the book untrustworthy and misleading. It is a commendable ambition to instruct engineers in the mysteries of reinforced concrete, and a handbook on this subject should be a convenience for designers. However, the reviewer regrets that it is his duty to give his opinion that this book is fundamentally in error in so many ways that it is not worthy of a place in the working library of an engineer. Much remains to be learned of reinforced concrete and there are many points about which opinions may differ widely, but certain fundamental principles cannot be questioned. In this book the principal tables and computations are based upon methods of treatment which violate the fundamental principles of mechanics. The kind of error characteristic of the book may be illustrated by the method used in determining the resisting moment of a reinforced concrete beam. This resisting moment is found by multiplying the unit stress in the steel reinforcement by the area of the steel by the distance from the center of the steel to the neutral axis of the beam, and the moment of the compressive stress of the concrete is thus left out of consideration. Of course, if only the tension is to be considered, the moment arm should be taken as the distance from the center of the tensile stress to the center of the compressive stresses (moment of the couple). In order to find the compressive stress at the top of the beam, the author calculates the moment of inertia of the rectangle forming the concrete section about the neutral axis of the beam, and this expression is used in the ordinary beam formula without taking further consideration of the moment of the steel stress and without making allowance for the concrete being weak in tension. The author uses these erroneous methods and formulas in making his calculation of the stresses existing in the two beams tested by himself "to justify the use of various constants and coefficients in preparing the tables," and gravely concludes that in Beam No. 2 the tensile stress developed in the steel was 64,000 lbs. per sq. in., the compressive stress in the concrete 4,610 lbs. per sq. in., and the tensile stress on the concrete at the level of the steel 5,200 lbs. per sq. in. Calculated by formulas ordinarily accepted in such work, the stress in the steel is approximately 31,000 lbs. per sq. in., and the compression in the concrete is, say, less than 2,700 lbs. per sq. in.; and it is now usually conceded that the concrete at the level of the steel cannot be considered to take much tension.

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The author then assumes the following values for working stresses to be used in designing and as a basis for the tables: for tension in the steel reinforcement, 15,000 lbs. per sq. in., and for compression in the concrete, 850 lbs. per sq. in. These values he considers will give a factor of safety of 3½. He then proceeds to give, in the tables, the dimensions of over 200 sizes of beams, increasing in width by 1-in. increments and in depth by 2-in. increments, and ranging from 2½ ins. and 3 ins. wide and 6 ins. deep to 20 ins. wide and 80 ins. deep. For each size of beam he selects the amount of reinforcement which he considers will bring out the assumed stresses in both steel and concrete when calculated by the methods already mentioned. The percentage of reinforcement used varies from more than 3% for the small beams to about 1.8% for the large sizes. These tables give, among other properties, the "safe bending moment" based upon the method previously noted. Instead, then, of a tensile stress of 15,000 lbs. per sq. in. being developed in the steel with the specified safe bending moment, as stated in the text, the methods of calculation usually accepted will show a stress from 7,500 to 8,000 lbs. per sq. in. for the larger sizes, and instead of 850 lbs. per sq. in. compression in the concrete the real stress is in the neighborhood of 500 lbs. per sq. in. The best that can be said of the results of this erroneous method of reasoning used is that these particular errors are on the safe side. However, such violations of the principles of mechanics unfit the book for general use. Another table gives the safe loads for the 200 sizes of beams for varying lengths of span, the longest span given for the 20 × 80-in. beam being 78 ft. Tables are also given for continuous beams, made up in the same way. In no case is more than one percentage of reinforcement given.

The author's treatment of resistance to vertical and longitudinal shear is original but wholly unreliable. He makes the longitudinal shear nine-fifths of the vertical shear. He uses 350 lbs. per sq. in. as the ultimate shearing strength of concrete, and bases his factor of safety upon this. He uses 100 lbs. per sq. in. in one of the columns of the tables for safe shearing stress calculated by the method used. It is stated that this gives a factor of safety of 3½, notwithstanding that Beam No. 2, which the cut shows as breaking by diagonal failure, held only 110 lbs. per sq. in. in shear when figured by the same method. Evidently an occasional beam will break at supposedly safe loads if designed in this way. Instead of a factor of safety of 3½ the beam is likely to fail. The author seems not to recognize diagonal tension, although the failures he is trying to guard against are diagonal tension failures rather than shearing failures. The suggested use of a horizontal bar at the neutral axis to take longitudinal shear is a further example of the vagaries of the book.

The tables for floors are subject to the criticism given to the beams. The safe loads given for columns are questionable and the method of reinforcement is not good. The author shows his faith (or shall it be called nerve?) by carrying his design for beams into the tables for roof trusses which run up to a span of 100 ft. The connections at panel points are only vaguely described. The tables of comparative cost of reinforced concrete, steel, cast iron and wood are of little value because of the round numbers used in the basis of costs.

An example of the wild form of statement made is here quoted:

> As there are several cases in actual practice where the equality of the sections of steel and concrete in the layer in question actually exists, and where, from the actual loading, the stress per square inch of steel figures 15,000, it is but fair to assume that the stress caused in the concrete thereby is one-tenth of this, namely, 1,500 lbs. per sq. in.
>
> Critics who are wont to call the ultimate tensile strength of concrete 200 to 300 lbs. per sq. in. will no doubt either laugh this reasoning to scorn, or will refuse to use a construction which imposes such exacting conditions upon a material weak in itself, before stopping to consider that we are not dealing with elements alone, but with a carefully selected (or at least it should be) combination of materials. That this combination has proved itself in practice to be equal to the conditions just stated should, until experimenters have shown otherwise, be evidence enough to justify its adoption.

Reinforced concrete is a promising form of construction, but all must agree that it has limitations and that its designs must be intelligently made and skillfully and carefully carried out. Evidently the time has not yet arrived when a handbook of tables can be used in the same manner as a Carnegie or Cambria steel handbook, for reinforced concrete beams may not be cut off like steel beams to suit all spans and methods of supporting and loading. Even if the numerous tables were correct, it would not be well to put such a book into the hands of a novice. With tables and methods fundamentally wrong, a book must stand discredited. One wonders how such faults escaped the watchful eye of the publisher. Many engineers who have examined designs used for reinforced concrete in buildings and elsewhere have wondered that there have not been more serious failures, and some have even doubted the wisdom of using this form of construction. Reinforced concrete ought to become an accepted type of engineering construction. To make it such will require the same study and investigation which has been put into the development of other forms of construction. A book like this will tend to discredit reinforced concrete and retard its development, and it is unsafe to put it in the hands of young engineers.

MECHANICS FOR ENGINEERS.—A Text-Book of Intermediate Standard. By Arthur Morley, M. Sc., University Scholar (Vict.), Senior Lecturer in Engineering in University College, Nottingham. London, New York and Bombay: Longmans, Green & Co. Cloth; 5 × 7½ ins.; pp. 282; 190 figures in the text. 4s.; American price, $1.20, net.

A very clear and concise presentation of the principles of mechanics is given in this book. It is distinguished by two features: (1) the use of the pound and foot system exclusively, with only occasional references in examples to metric units; (2) the avoidance of calculus forms of expression. Both features have evident value, which is enhanced by careful precision and clearness of language. The course of development of the subject is: Velocities and Accelerations, Forces and the Laws of Motion, Work, Statics of Concurrent Forces, Friction, Center of Gravity, Moments of Inertia. A chapter giving the elements of Graphic Statics is appended, and a chapter on simple harmonic motion is interpolated near the middle of the book. The range of contents appears to have been very judiciously selected, and the book commends itself as a thoroughly serviceable exposition of the fundamental parts of mechanics. There is perhaps a slight weakness in the explanation of the relation between forces and accelerations, which relation is dogmatically stated by the second law of motion. This vital point of mechanics deserves more emphatic statement and fuller discussion. But the weakness, if it may be called such, lies only in overbriefness, and not in any inaccuracy or incompleteness of statement.

THE BUSINESS OF MUNICIPALITIES AND PRIVATE CORPORATIONS COMPARED.—Data That Proves Municipal Ownership Waste Exceeds Corporate Profit. By M. J. Francisco, Past President National Electric Light Association of the United States, Author of "Municipal Lighting," etc. Rutland, Vt.: M. J. Francisco & Son. Paper; 5¾ × 8½ ins.; pp. 136. $1.

Mr. Francisco has long been the arch-opponent of municipal ownership, at least among the few who write in an outspoken manner on the negative side of the question. He here restates his main arguments, revises and extends his collection of specific "failures" of municipal electric lighting plants and of newspaper and other quotations against municipal ownership, and gives some comparative cost-of-service figures for many plants. The latter, on their face, show a large average excess of cost for municipal as compared with private ownership, but, like nearly all figures on municipal and private ownership, these take practically no account of variations in local conditions. Although the pamphlet is conceived and executed on a partisan basis throughout, it is well worth the attention of any one who is capable of considering it in a judicial spirit, or who wishes anti-municipal ammunition, regardless of partisanship. The value of the data for those on both sides of the question would be increased if their origin were more frequently stated.

A Text-Book on the Metallurgy of Iron and Steel.

Reviewed by Bradley Stoughton.*

ELEMENTARY PRACTICAL METALLURGY.—Iron and Steel. By Percy Longmuir, Carnegie Research Scholar and Medallist, Iron and Steel Institute. London, New York and Bombay: Longmans, Green & Co. Cloth; 5 × 7½ ins.; pp. 269; 64 figures, partly in the text. 5s., net; American price, $1.60, net.

This book is an interesting and concise statement of certain details of iron and steel metallurgy. It omits some subjects which should be included in a text-book, as, for instance, the metallography of cast iron and low carbon steel, and it gives disproportionate attention to others, such as malleable cast iron. Some of the descriptions are true only for local conditions, and several of the sentences are carelessly formed and liable to misconstruction, while many of the author's similes, though they explain his meaning clearly to one familiar with the subject, might lead a beginner to misconceptions.

It is from the standpoint of accuracy, however, that the final judgment of this book must be made. The reviewer has noted 44 misstatements of importance in the text, not including typographical errors or matters about which there might be a difference of opinion. Any ten of these misstatements would make it unwise to employ the book alone for the use of beginners or students. The most serious errors are in the statements of fundamental principles of metallurgy, and particularly metallurgical chemistry, though the descriptions of furnaces and processes are not always correct. Limited space prevents a discussion of all these mistakes, and a few typical examples will have to serve as illustrations:

On pages 167 and 245 the author gives tests of a number of steels varying greatly in analysis, the carbon, for example, ranging from 0.04 to 1.47%, and several of them belonging to the class of "alloy steels." He quotes the mechanical properties of these different steels, after having heated them all to 1,000° C. and cooled in air, a treatment which he designates as "normalizing." He emphasizes his statement that this treatment brings the steels of these various analyses into one uniform condition. A little reflection, however, would convince him that, though heating to 1,000° C. is good for certain of the steels mentioned, it would be abusive treatment for some of the others. This is one of the first principles of heat treatment of steel, and a clear understanding of its importance and explanation cannot be too strongly urged.

On page 189, speaking of the Bessemer process, he says:

> The rising temperature, due to the oxidation of the silicon, gradually increases the size and luminosity of the flame.

Every metallurgist knows, or should know, that the luminosity of flames is due to the heating to incandescence of separated particles of carbon, and that the size and luminosity of the Bessemer flame is dependent upon the rapidity of the combustion of the carbon in the iron. In nine cases out of ten the oxidation of silicon has not even an indirect connection with the size and luminosity of the Bessemer flame, nor even with the rise of temperature during the particular period of the process when the flame exists, for this period begins only after oxidation of silicon has ceased and that of carbon commenced.

On page 183 he says:

> To eliminate these blow-holes, or, in other words, the occluded gas which causes them, 4 or 5 ozs. of ferro-manganese are added, and the steel "killed" or given another fire until it is "dead melted" . . . . . The manganese present throws silicon from the walls of the crucible into the steel, a joint reaction which appears to effectually expel the gases of the steel, leaving less to escape during solidification. Howe, in his "Metallurgy of Steel," does not hold this view, but argues that the absorption of silicon increases the solvent power of the steel for gas, thus enabling it to retain in solution, on solidification, the gas which it retains when molten. Practical experience, however, does not hold to this view, but rather to the one that the gases are expelled by the "killing fire."

To contradict a standard authority by an unsupported reference to "practical experience" implies the lack of a real reason. It may not be known to Mr. Longmuir that the man he thus contradicts had many years' practical experience in the manufacture of steel before he became the famous writer that he now is. However, the best answer is found in Mr. Longmuir's later contradiction of himself and agreement with the principle laid down by Professor Howe, as follows (page 227):

> A consideration of the foregoing leads to the following conclusions:
> 2. The presence of silicon and manganese lead to the retention of the gases until solidification is complete, hence preventing the formation of blow-holes.

On page 204 the author states that the valves of the open-hearth furnace are reversed at intervals of half an hour. As a matter of fact, 20-minute reversals are now practically universal, and lengthening the period to 30 minutes would lead to non-uniformity of temperature.

Lastly, on pages 65 to 75, inclusive, the author gives a description of the chemistry of the blast furnace in which the errors are exceedingly numerous.

The best chapters of the book are I. and II., on "Refractory Materials" and "Metallurgical Fuels," respectively. Chapters X. and XI., on "Malleable Cast Iron" and "Wrought Iron," respectively, also contain some good information of an elementary character. The remainder of the book does not redeem itself, although, if the photomicrographs were in focus so as to reveal the structure of the components, and were accompanied by suitable analyses, a beginner would find greater benefit in reading the last 20 pages, on the subject of Metallography and Heat Treatment. The photomicrographs facing pages 164, 165 and 166, on the other hand, leave nothing to be desired.

There exist already at least two text-books on the "Metallurgy of Iron and Steel," with which Mr. Longmuir's book could never hope to compete, even if freed from its numerous errors, because its subject matter is not so well proportioned or presented. Both these text-books, like Mr. Longmuir's, are devoted principally to English practice. At present there is none dealing with American practice and written solely for the use of students and beginners. Such a one would, indeed, be heartily welcomed. America now produces almost as much steel as the rest of the world put together, and leads the world in all details of practice except the manufacture of the highest grades of wrought iron and crucible steel. In two minor processes, viz.: the successful production of basic Bessemer steel and the utilization of blast furnace gases, Germany takes first place.

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Parks and "Practical Politics."

THE FIRST COUNTY PARK SYSTEM.—A Complete History of the Inception and Development of the Essex County Parks of New Jersey. By Frederick W. Kelsey, Vice-President of the Original Commission. New York: J. S. Ogilvie Publishing Co. Cloth; 5 × 8 ins.; pp. 300; illustrated. $1.25.

The park system of Essex Co., N. J., as originally designed, was to be a combination of (1) highly developed large and small city parks; (2) of immense reservations of rural areas, selected for their natural beauties of forest, stream, hillside and distant views; (3) of parkways or boulevards connecting the various parks and reservations. The city parks and the mountain reservations have been provided on a magnificent scale, but on the parkways little progress has yet been made. Moreover, in the opinion of the author of this book, the development of each park has been carried out with too little regard for the needs of the parks and reservations as a whole, so that with this fault and with the failure to provide parkways the county park system is largely lacking in systematic development.

The author traces the inception and growth of the park system in an interesting manner, but devotes so much space to a detailed account of the political, legal and financial sides of his subject that he has, or gives, little space for the natural and artificial features of the parks and reservations themselves. This is particularly unfortunate, since the results achieved, however lacking in some respects, are well worthy of detailed description.

The book is, in the best sense of the term, a political pamphlet, designed to show, from the viewpoint of a baffled one-time park commissioner, how "practical politics" to a hap- of parks plan, and ent, com- corporate completely k system as may be t was de- placing of igned for the park- that fea- its author and park While we ttempt of ne knows ls of poli- ew Jersey ferences of fellow park ed on both sides. The people of Essex Co. may well be congratulated for the conversion of unsightly areas, within thickly settled communities, into health-giving and beautiful breathing spaces, and for the preservation of the natural charms of thousands of acres of mountain top and valley. If the same or better results could have been achieved for less money, and if the parkway system could have been provided, there would have been still more reason for congratulation.

INTER-COLONIAL IRRIGATION COMMISSION.—Interim Report. (C. D. H. Braine, Secy., Executive Engineer, Irrigation Department, Transvaal.) Pretoria, Transvaal: Pub. Doc. Paper; 8 × 12¾ ins.; pp. xxxviii. + 166; many sample sheets of account books, including three folding plates. 7s. 6d. American price, $3.

An exhaustive investigation of the irrigation problems of the Transvaal is proposed, judging by the eight "Terms of Reference" to the commission named above and the fact that the present report deals only with the Reference on underground waters, particularly in the dolomite formation, and with special reference to "the diversion of such water from public streams and fountains to the detriment of the public." The commission consists of six members, including Mr. W. L. Strange, M. Inst. C. E., Director of Irrigation, Transvaal. The volume is made up of a brief report proper, including recommendations for the control of underground waters, and of three appendices. One of these is an interesting "Note on the Law of Subterranean Waters," by Mr. J. W. Wessels (Chairman of the Commission), Judge of the Supreme Court, Transvaal; one summarizes recent private bill legislation in England for the protection of underground water; one digests or summarizes the evidence taken by the commission, and the final appendix, which occupies most of the volume, gives the detailed evidence on the subject of the report, as drawn from engineers, geologists, land-owners and farmers. Among the recommendations of the commission we note: That farmers be allowed free pumpage of underground water for their own use for cattle and for irrigation; that traffic in underground water be prohibited, except when for the "public advantage," in which case "legislative sanction" must be secured; that the government be given large powers of control of such waters; and

> That it is unnecessary to prove that water in the dolomite formation flows in channels. That this be accepted as being so prima facie by the Courts, and that if the Judge thinks that the facts establish a connection between the pumping and the diminution of the water in a stream, he can prevent the pumping to such an extent as he thinks fit. This rule of evidence to apply to all cases where the boring and pumping were commenced before, or after, the passing of the legislation.

TRANSACTIONS OF THE AMERICAN CERAMIC SOCIETY.—Volume VII., Part III. Containing Papers and Discussions Read at the Meeting Held at Birmingham, Ala., Jan. 30 and Feb. 1, 1905. With Some Other Contributions. Columbus, O.: The Society (Edward Orton, Jr., Secy.). Paper; 6 × 9¼ ins.; pp. 285 to 454; illustrated.

This volume contains a round dozen of papers relating to various subjects of interest to the manufacturer of ceramics. Two papers on the heat conductivity of refractory clays and a paper on "Measurement of Settle in Brick Kilns" contain matter of some general interest to engineers.

The Adjustment of Observations.

Reviewed by George C. Comstock.*

THE ADJUSTMENT OF OBSERVATIONS.—By the Method of Least Squares, with Applications to Geodetic Work. By Thomas Wallace Wright, M. A., C. E., Professor Emeritus, Union College. With the co-operation of John Fillmore Hayford, C. E., Chief of the Computing Division and Inspector of Geodetic Work, U. S. Coast & Geodetic Survey. Second Edition. New York: D. Van Nostrand Co. Cloth; 5¾ × 8¾ ins.; pp. 298; 26 figures in the text. $3 net.

For nearly a quarter century Wright's Adjustment of Observations has held the chief place among American works dealing with the theory and the application of the Method of Least Squares, and the appearance of a modified second edition shows that however limited the public to which the book appeals, it has found within its sphere a *raison d'etre*. As originally published, the work represented, primarily, although not exclusively, the practice followed in the adjustment of the geodetic work of the U. S. Lake Survey. But the new edition stands upon a somewhat different footing, bearing upon its title page the name of one of the chief officers of the U. S. Coast & Geodetic Survey, whose co-operation marks the work as an authoritative exposition of the methods of numerical adjustment at present used in that bureau. From this standpoint the treatise must command the attention and interest of every American engineer and astronomer engaged in geodetic work, and may well serve as a reference volume for higher instruction in schools of engineering. It is, however, strong meat, and the beginner may do well to acquire his first knowledge of the subject through some of the less elaborate treatises.

The material of the present volume is compressed into two-thirds the bulk of its predecessor, and, as compared with the earlier edition, it is more nearly a text-book of triangulation, the sections upon base-line measurement, leveling, graduation errors and the calibration of thermometers being either much reduced in extent or entirely eliminated. Per contra, a new chapter by Mr. Hayford, justly designated as "suggestive rather than complete," devotes a score of pages to the method of least squares considered as a criterion for the selection of methods of observation.

Within its own province, the book is fairly to be designated as a sound and creditable exposition of methods employed in the official adjustment of American triangulation, many of them, as is there pointed out, being original in the surveys with which the authors have been connected. To the reviewer, the most serious defect of the book appears to be an insufficient presentation of the numerical work represented by the formulae of the text. As compared with the generous forms for computation and illustrations of numerical work presented by Oppolzer within a single chapter of a work primarily devoted to other purposes, the corresponding parts of Wright and Hayford seem scantily worked out and inadequate as a guide to the practical application of their methods. The typographical difficulty of presenting such matter within the limits of an octavo page may in part excuse its absence, but a similar justification can hardly be urged for such blemishes as the rather frequent occurrence of misspelled words, the failure to discriminate between the symbols s and " as abbreviations for seconds of time and arc, respectively, and for occasional cumbrous and obscure sentences, such as "The actual curve in each case showed about 13 times as many errors as the theoretical curve greater than 4½ times the computed probable error, and about 79 times as many greater than 5¾ times the computed error." Although, broadly speaking, such defects are of minor consequence, it is hoped that they may be remedied in a future edition, and the authors are to be congratulated upon the substantial excellence of their work.

IMPROVEMENT OF PUBLIC HIGHWAYS.—Bulletin No. 11. Department of the State Engineer and Surveyor of the State of New York. Albany, N. Y.: Pub. Doc. Paper, 6 × 9 ins.; pp. 33.

The progress to the close of 1905 and the present status, in detail, of State highway work in New York are set forth in this pamphlet.

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A New Edition of Bell's Electric Power Transmission.

ELECTRIC POWER TRANSMISSION. — A Practical Treatise for Practical Men. By Louis Bell, Ph. D., M. Am. Inst. E. E. Fourth Edition, Revised and Enlarged. New York: McGraw Publishing Co. Cloth; 6 × 9¼ ins.; pp. 721; 341 figures in the text, 24 plates and many tables. $4, net.

There is an interesting table on the last page of this volume which lists those American transmission systems using a line-pressure of 20,000 volts or higher. The table names more than 100 plants and credits them with capacities which total somewhat above 700,000 KW. These figures speak impressively for the commercial and industrial importance of long-distance electric power transmission. The art is so young, moreover, and employs such novel means, that its technical interest is far greater than would be indicated by the number and capacity of the plants. Under these circumstances there is abundant material and ample room for a treatise summarizing the problems, methods and data of the subject. Bell's "Electric Transmission of Power" by its title purports to be such a treatise.

The work has not the advantage of taking up its subject de novo in its present-day status, since it is a re-edition of a work written ten years ago. The work of the author in revising it was (as is inevitable in most such cases) evidently hampered by the general scheme and details of the original edition; the revision and amplification bears the character of interpolation. The result is that the book seems old-fashioned, not to say obsolete, in its general layout, and heterogeneous and inadequate in detail.

Over one-half of the bulky mass of pages treats of matters which have no essential relation to electric power transmission: matters such as steam engines, boilers, water-wheels, principles of electric machines, hydraulic development, electrical instruments, and the like. The remainder, whose nature is strictly appropriate to the subject, is far from being either thorough or comprehensive. Neither the electrical nor the mechanical problems which had to be solved before long-distance transmission at 50,000 volts and higher was commercially feasible are clearly presented and discussed, nor are the methods and devices which were developed to overcome them described in a manner commensurate with their importance. The high development of the art is not worthily represented by the book.

The book is very readable. Its style and language are everywhere simple enough that the book may be read without effort and without the aid of mathematical ability. Thus both the contents and the style of the text make the book a "popular" work and not an engineer's treatise. Bearing in mind this vital limitation, the reader will find a great deal of information, on electric power transmission and other things, scattered through its 700 pages, and in the absence of a treatise on the subject the book fills a useful place in electrical literature.

GASWORKS ACCOUNTS AND MANAGEMENT.—By George Helps. London, Eng.: The "Gas World" Offices. Cloth; 4¾ × 7½ ins.; pp. 151; two folding plates. 5s.; American price, $2.

Compressed in this small book is an outline of a complete system of gas works accounts and a considerable amount of information on the management of works and on certain phases of charging for gas. The author prefers an engineer for a manager of gas works, where one can be found who possesses "sound commercial knowledge, which, of necessity, must embrace accountancy." He lays stress upon the value of comparisons between the accounts of different works, which involves some standardizing of methods. A long chapter is devoted to discounts, including reductions to large consumers. In considering this subject the author might profit by a study of the paper on "Methods of Charging for Gas," by Mr. Alfred E. Forstall, read before the last meeting of the American Gas Light Association and reprinted in Engineering News for Jan. 11, 1906.

In the course of his discussion the author makes some acute remarks on two classes of managers, one devoted to the interests of his works and the gas profession and the other chiefly concerned with his personal standing and chances of preferment. The book also contains, now and then, some pungent criticisms on municipal management and mismanagement.

CREMATORIA IN GREAT BRITAIN AND ABROAD.—By Albert C. Freeman, M. Soc. Architects, Author of "Planning of Poor-Law Buildings and Mortuaries," etc. London, Eng: St. Bride's Press, Ltd. Cloth; 8¾ × 11¼ ins.; pp. 35; illustrated.

Some historical notes are followed by a few paragraphs on the general design of crematoria for the human dead, after which there are given brief descriptions of crematoria in Great Britain, Germany, Italy, France, Switzerland, the United States, Sweden, Canada and Australia. A few of the illustrations show details of the furnaces, but these are mostly poor. There are a number of plans, pen-sketches and half-tone views of buildings, chapels and columbaria, used in connection with crematoria. The British statistics for the number of bodies burned come down to the close of 1904; those for other countries are still older.

THE LAST SPIKE.—And Other Railroad Stories. By Cy. Warman. New York: Charles Scribner's Sons. Cloth; 4¾ × 7 ins.; pp. 286. $1.25.

These short stories, by a well-known popular magazine writer, tell of adventures on railway surveys, in railway locomotives and cars and elsewhere. Some of the best of the stories have the Canadian Northwest as their scene of action.

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"The book appears to be one of the most convenient handbooks for the structural engineer on the market."—C. H. Winslow, Librarian, C. E. Society of St. Paul.

A review of this book recently published makes the false assertion that the book contains principally tables taken without credit from other books. The publisher of that review has so far ignored the author's letter showing the reviewer's allegations to be groundless.

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Recent Mathematical Books.

Reviewed by Mansfield Merriman.*

AN INTRODUCTION TO THE INFINITESIMAL CALCULUS.—Notes for the use of Science and Engineering Students. By H. S. Carslaw, F. R. S. E., Professor of Mathematics in the University of Sydney. London, New York and Bombay: Longmans, Green & Co. Cloth; 5¼ × 8¼ ins.; pp. 103; 20 figures in the text. $1.60, net.

A COURSE IN PRACTICAL MATHEMATICS.—By F. M. Saxelby, Head of the Mathematical Department, Municipal Technical Institute of Belfast. London, New York and Bombay: Longmans, Green & Co. Cloth; 5¼ × 8¼ ins.; pp. 438; 200 figures in the text. $2.25, net.

The book by Professor Carslaw contains eight chapters, two of which are devoted to analytic geometry, four to the differential and two to the integral calculus. The author's attempts to present the essentials of these important branches of mathematics in a brief space may be said to be fairly successful, but greater success would have been attained had he introduced numerical exercises in the text. The examples to be worked by the student contain, it is true, some numerical problems, but it is nevertheless important that a few should be fully worked out as a guide. In developing the rules of the calculus the author mainly uses the method of limits and differential coefficients, while the method of infinitesimals, although prominently mentioned in the title, receives only a brief treatment in two pages. For a short course in calculus it seems better to use only one method, since the new ideas are not quickly grasped by the student.

The book by Professor Saxelby contains a large amount of matter covering geometry, trigonometry, algebra, functions, differential and integral calculus, and vectors, together with applications in mechanics and physics. While the development is not so strictly logical as that employed in works on pure mathematics, the applications and exemplifications are more clearly presented, and this feature renders the book specially serviceable to engineers, both young and old. Numerical exercises and graphic illustrations are given at every step, and the admirable manner in which these are explained is worthy of commendation. The chapters on vectors and their uses in physics may in particular be noted as presenting a difficult subject in a clear and simple manner. Altogether the volume covers most of the mathematical work usually given in engineering colleges, an acquaintance with elementary algebra and geometry being required as a prerequisite. The method of plotting functions on squared paper is employed with great advantage. There is, indeed, no way better than this to enable a student to thoroughly understand the meanings of functions and equations, and its introduction at an early stage in mathematical study is advisable. In general, the book assumes the student to have a good knowledge of mechanics and physics, so that it is perhaps better adapted for reference than as a text-book for classes in technical schools, although the absence of an index considerably lessens its value as a reference work. A graduate of an engineering school, desiring to review his mathematics, will find this book an excellent one for that purpose.

LINK MOTIONS, VALVES AND VALVE SETTING.—By Fred H. Colvin. New York: The Derry-Collard Co. London: The Locomotive Publishing Co. Flexible cloth; 4 × 6 ins.; pp. 82; 43 figures in the text, and one folding plate. 50 cts.

The common reversing valve gear, in practically universal use on American locomotives, hoisting engines, rolling mill engines and for nearly all locations where reversing engines are used, is commonly known as the Stephenson link valve motion. Mr. Colvin opens his book with the statement that the real inventor of this widely used mechanism was not the famous Robert Stephenson, but a draftsman named Williams, who was employed in the drawing room of the Stephenson works. The book is a condensed treatise on the link motion valve gear, which will be found useful by any draftsman or designer engaged in this class of work. The concluding chapters describe various types of slide valves and piston valves, and other types of reversing valve gears besides the common link motion. Regarding these other motions the author suggests that "a pretty good idea of wearing parts can be had by simply counting the joints or pins." In our opinion such a comparison is extremely superficial; and there is good reason to believe that a more thorough comparison would show some of the newer forms of valve gear to be superior to the old-fashioned link. It is worth while to add a few additional joints and what may seem to be additional complications, if by so doing the eccentrics and all the train of ills which accompany them can be dispensed with.

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NATIONAL ENGINEERING AND TRADE LECTURES.—Assisted by the Board of Trade, Colonial and Foreign Offices, Colonial and Foreign Governments and Leading Technical and Trade Institutions. Edited by Ben H. Morgan. London, Eng.: Archibald Constable & Co., Ltd. Chicago, Ill.: W. T. Keener & Co. Boards; 7 × 10½ ins. $2.40 net, each.

Vol. I. British Progress in Municipal Engineering. A Series of Three Lectures by William H. Maxwell, Assoc. M. Inst. C. E., Borough and Water-Works Engineer, Tunbridge Wells Corporation, Author of "Refuse Destructors," etc., President of the Institute of Sanitary Engineers, London. 1. General—Road Engineering and Maintenance. 2. Main Drainage, Sewage Disposal, Destructors. 3. Water Supply. Pp. 182; numerous folding and other plates.

Vol. II. British Progress in Pumps and Pumping Engines. By Philip R. Björling, Consulting Engineer, Author of "Pumps and Pump Motors," "Pumps: their Construction and Management," etc. Pp. 92; 93 plates.

Vol. III. British Progress in Gas Works' Plant and Machinery. By C. E. Brackenbury, A. M. Inst. C. E., Member of the Institution of Gas Engineers, etc., Author of "Modern Methods of Saving Labor in Gas Works," etc. Pp. 105; 113 plates.

The first of these volumes was noted in our issue of April 13, 1905, and at the same time the plan and general characteristics of the series was outlined in some detail. The series has since been made more readily available in this country through the action of the American publishers, named above. The second and third volumes in the series are of the same general character as the first volume; that is, they consist, for the most part, of brief classified descriptions of the output of named British manufacturers. The volume on gas works is the most dignified and technically serviceable of the three, partly because the subject in hand lends itself to brief, monographic treatment. This volume, also, has the most comprehensive bibliography of the three. Each volume contains a directory of manufacturers.

LOCOMOTIVE TESTS AND EXHIBITS AT THE LOUISIANA PURCHASE EXHIBITION, ST. LOUIS, MO., 1904.—Philadelphia, Pa.: Pennsylvania Railroad Co. Half morocco; 6¼ × 9¼ ins.; pp. 734; over 900 illustrations (including a large number of folding plates of detail drawings). $5.

Of this handsome volume 565 pages are occupied by the descriptions and records of tests of eight locomotives, which are accompanied by tables and diagrams; in addition, there are about six folding plates of drawings of each of these locomotives. About 40 pages are devoted to the summaries and conclusions based upon the tests, and 100 pages to a description of the testing plant and auxiliary apparatus, the meth[ods] of conducting and recording the tests, an[d] view of the general purposes, the organizat[ion]. The remaining few pages describe the [tests] other features of the Pennsylvania R. R[its]. A review of the tests, together with [editorial] summary, was published in our issu[e] Feb. 15, 1906. The testing plant was desc[ribed] in our issues of Nov. 26, 1903, and May 1[4]. An abstract of the official report of t[he] first test appeared in our issue of April 20, 19[06].

THE BUILDING MANAGER AND OWNE[R]. Published Monthly in the Interest of Buildings. [Vol.] I, No. 1. January, 1906. Chicago, Ill.: Buil[ding] Manager Publishing Co., 315 Dearborn St. Paper; 12 ins.; pp. 24; illustrated. $2 a year.

Among the articles of a technical [or] semi-technical character in the initial num[ber] of this new monthly is one on "Purchasing" and another on the "Mechanical Equipment of Public Buildings." The last-named is by Geo. [W.] Nisle, M. Am. Soc. M. E.

THEORY AND PRACTICE OF PAINTING ON METAL.—By A. H. Sabin, M. S. New York: Edward Smith & Co. (45 Broadway). Stiff paper; 6 × [9] ins.; pp. 65; illustrated.

Although sent out as a trade publication, this pamphlet is well worthy of place in any engineer's working library. It is divided into four parts, the second and third of which contain the author's specifications for painting on structural steel, first, for the best work, and, second, for ordinary work. Part I. is a general discussion of the theory and practice of painting on metal, and Part IV. describes various anti-corrosive coatings.

THE AMERICAN RAILWAY MECHANICAL AND ELECTRICAL ASSOCIATION.—Report of the Third Annual Convention, Held in the South Building, Philadelphia Museum, Philadelphia, Pa., Sept 25 and 26, 1905. (S. Walter Mower, Secy., 12 Woodward Ave., Detroit, Mich.). Stiff paper; 6 × 9 ins.; pp. 295; illustrated.

Among the subjects covered by papers and discussions are power distribution, power stations and station loads and rail joints, the latter by F. G. Simmons and others. Hereafter this society will be known as the American Street & Interurban Railway Engineering Association.

TESTS OF CEMENT.—By A. Marston, Director of Engineering Experiment Station. Bulletin No. 1, Vol. III., Iowa State College Engineering Experiment Station, August, 1903. Ames, Ia.: The Experiment Station. Paper; 5¾ × 8½ ins.; pp. 40; 14 figures in the text.

This bulletin has been prepared evidently to supply the non-technical man with such information regarding the production, manufacture, classification, properties and testing of hydraulic cement as will enable him to exercise some judgment in its selection and manufacture for common uses. In addition to this general discussion there are records of several years tests of cements in the college laboratory. This laboratory makes tests of cement for residents of the state at the bare cost of the work.

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The Future Resources of the Earth.

MAN AND THE EARTH.—By Nathaniel Southgate Shaler, Professor of Geology in Harvard University. New York: Fox, Duffield & Co. Cloth; 5 × 7¾ ins.; pp. 24[illegible] $1.50 net.

More than forty years ago a large book, entitled "Man and Nature," was written by George P. Marsh, an American philologist and statesman, who collected one of the most notable private libraries of his time (now in the possession of the University of Vermont). In the volume named Mr. Marsh aimed (first edition, New York, 1864)

to indicate the character and, approximately, the extent of the changes produced by human action in the physical condition of the globe we inhabit; to point out the dangers of imprudence and the necessity of caution in all operations which, on a large scale, interfere with the spontaneous arrangements of the organic or the inorganic world; to suggest the possibility and the importance of the restoration of disturbed harmonies and the material improvement of waste and exhausted regions; and, incidentally, to illustrate the doctrine, that man is, in both kind and degree, a power of a higher order than any of the other forms of animated life, which, like him, are nourished at the table of bounteous nature.

Mr. Marsh's volume, with its 550 octavo pages, loaded with foot notes, was justly considered a remarkable production in its day, and still abounds with interest to those who can find or are willing to take the time to read it.

In marked contrast with Mr. Marsh's large volume and in several other ways illustrative of the changes of forty years, is the small book now before us, in which Professor Shaler has

endeavored to set forth certain reasons why there should be a change in the point of view from which we commonly regard the resources of the earth. As a teacher of Geology [he continues], I have seen that there is a complete lack of understanding in our communities as to the duties we owe to our successors in their use of these limited resources. In this regard our conduct is like that of children who take the good that comes to them with no thought of the hereafter. *This attitude of men as regards the future of the material values of the earth notably contrasts with that they hold to the moral and political future of their kind.* [The italics are ours.]

It will be seen, from the two quotations, that in one important respect the aim of the two books is the same: to call attention to the need of bringing man into harmony with nature, especially with a view of the future needs of man.

Professor Shaler has given us, in a form so compact and interesting as to leave the busiest man no excuse for not reading it, a review of man's relations towards the natural resources of the earth, together with a forecast of the periods through which the most important of these resources may be expected to last and the scientific probabilities of the future of nature on the earth and of the last of earth and man. Could one ask for a more inviting program?

The opening chapter, on "Earth and Man," is an excellent preview of the subject in hand. Then follow world-ranging discussions of the future of power, including coal, oil, wind, water and the tides; the exhaustion of metals; and the possibilities of winning land by irrigation and drainage. The Nile is given a chapter by itself. The maintenance of the soil, including both its protection from erosion, or washing to the sea, and the perpetuation, and where need be the increase, of its fertility, next receive attention, after which the vast but less known food resources of the ocean are considered.

In discussing "The Changes to Come in the Human Period" there are some far looks ahead, but, as the quotation from the preface reminds us, we are all too prone to forget the material future of man on the earth.

One of the most telling and most needed chapters in the book is on "The Beauty of the Earth," comprising some noble pleas for the preservation of the wonders as well as the beauties of both animate and inanimate nature. Municipal, state and national parks and reservations are ably urged. A plea for preserving the Everglades of Florida is made, on account of their unique beauty and because they are the "dwelling place of the Seminole Indians," who are "the least changed of any aborigines in this country."

Speaking of reservations "as harborages for many mammals and birds which else are sure of being swept away," the author says:

Thus in Africa, in the region about the head-waters of the Nile, a reservation might well be established where a large part of the important mammalial species now near extinction could be preserved. There also, if the destructive process of civilizing the lower tribes of men could be avoided, we might hope to maintain sundry interesting varieties of our kind, now as certain to be destroyed as the giraffe or the African elephant.

We fear but a faint conception of the interest and value of the book has been given in the space available for its consideration, and especially of the suggestiveness of those portions dealing with sources of power, land areas reclaimable by irrigation and drainage and other subjects that cannot but appeal forcibly to engineers. But we hope enough has been said to lead many of the readers of this journal to become readers of the book as well.

A French Text-Book on Water and its Uses.

Reviewed by Allen Hazen.*

HYDRAULIQUE AGRICOLE ET URBAINE—By G. Bechmann, Engineer in Chief of Bridges and Roads; Member National Agricultural Society, etc. In Encyclopédie des Travaux Publics. Paris, France: Ch. Béranger. Paper; 6½ × 10 ins.; pp. 642; many illustrations. 20 francs; American price, $6.

M. Bechmann, the distinguished Chief Engineer of Water-Works and Sewers of Paris, has writen a text-book upon water and all the relations between it and the human race. The uses of water in agriculture, the drainage of land, the reclaiming of lands in river valleys, protection of shores, the management of dunes, are all treated at length, as well as the problems of municipal water supply, drainage, sewerage and sewage disposal. The ground covered is so broad that the treatment of it is necessarily brief, although clear and to the point.

The sanitary bearings of water supply and sewage disposal and the changes in the views held as to these matters in France in the last years are reflected to some extent. Illustrations are used freely, and show well the general character of the works described.

Heating and Ventilation.

NOTES ON HEATING AND VENTILATION.—By John R. Allen, M. Am. Soc. M. E., Junior Professor Mechanical Engineering, University of Michigan. Chicago, Ill.: Domestic Engineering. Cloth; 4½ × 6½ ins.; pp. 152; 35 tables and 34 figures in the text. $2.

VENTILATION OF BUILDINGS.—By William G. Snow, M. Am. Soc. M. E., and Thomas Nolan, Fellow Am. Inst. Archts., Assistant Professor of Architecture, University of Pennsylvania. New York: D. Van Nostrand Co. Boards; 3¾ × 6 ins.; pp. 83. 50 cts.

Each of these books is based on college lectures, and each promises to serve well its intended purpose. The purposes and methods, however, are quite different.

Professor Allen's book aims to cover both heating and ventilation, and is described as a "brief resumé" of lectures delivered by him to classes in heating and ventilation at the University of Michigan. The book is intended "primarily for the steam-fitter and designer of heating systems." It covers practically the whole range of the subject indicated. The use of a relatively small, but readable, type makes the contents of the book larger than would be supposed from the size and number of pages. Some tables of heat losses from radiating surfaces and some tests of pipe coverings, based on experiments made under the direction of Prof. M. E. Cooley, are included. There is a chapter on central heating, for a group of buildings, and in this some tunnel sections used by Professor Cooley are given. The work as a whole should fill the demand for a concise, handy, low-priced book on heating and ventilation, for both college and practical use.

The little book by Messrs. Snow and Nolan is intended as a "primer" of "the general principles of ventilation and of their application to different kinds of buildings." The mechanics of ventilation have been omitted, as being covered in another volume in the "Science Series." The subject matter of the present volume has served as "the basis of one part of a series of lectures by the authors in the Department of Architecture of the University of Pennsylvania." As a primer of ventilation the book deserves wide circulation, particularly among members of boards of health, physicians and others who lack, or think they lack, time to go beyond first principles. It might well be used in those medical and engineering schools that have not yet progressed to the point of providing competent professors to teach the important subject of ventilation.

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TESTS OF HIGH-SPEED STEEL TOOLS ON CAST IRON—By L. P. Breckenridge and Henry B. Dirks. Bulletin No. 2 of the University of Illinois Engineering Experiment Station, Urbana, Ill. Paper; 6 × 9 ins.; pp. 54; illustrated.

This bulletin deals with some comprehensive tests made with tools of various "high-speed" steels in turning cast iron specimens. The grades of steel used, the methods of tempering, and the methods of conducting the tests, are all described in full; while numerous tables and diagrams show the results obtained. The special apparatus employed is also described. At the end of the bulletin is a reference list of published articles on high-speed steels; also a number of instructions for hardening the steels used, as furnished by the makers. There is evidence of great care and thoroughness in the investigations and tests, and the bulletin is an excellent example of the work now being undertaken by this engineering experiment station. It may be noted, however, that the work of the station will not be confined to mechanical engineering, but will cover all branches of the profession.

WATER-SUPPLY AND IRRIGATION PAPERS, U. S. GEOLOGICAL SURVEY.—Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Paper; 5¾ × 9 ins.

No. 148: Geology and Water Resources of Oklahoma. By Charles Newton Gould. Pp. 178; 22 plates and 32 text figures.

No. 150: Weir Experiments, Coefficients and Formulas. By Robert E. Horton. Pp. 189; 38 plates and 16 text figures.

Paper No. 148 follows the usual lines of previous ones in this series dealing with the geology and water resources of individual states or territories. Mr. Horton's paper (No. 150) is a valuable compilation and discussion of weir experiments, coefficients and formulas, both foreign and American. Some previously unpublished studies by Mr. Horton, made at the Cornell Hydraulic Laboratory, are included.

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Autobiography of Sir Henry Bessemer.

SIR HENRY BESSEMER, F. R. S.—An Autobiography. With a Concluding Chapter [by his son]. London: "Engineering." Cloth; 9 x 12 ins.; pp. 380; 51 plates and 68 text figures. 16 shillings, net. American price, $5.50.

The annals of the engineering and metallurgical professions have been greatly enriched by the writing and publication of this autobiography. Fortunately, the autobiography, though not completed, was brought down to the close of the active career of its author, in 1872, or to the close of the Bessemer Saloon Steamer incident. This much was accomplished about a year before Mr. Bessemer died. Unfortunately, copious notes relating to the later years of his life were destroyed, in some manner unexplained, leaving but little material for the use of the son in his supplementary chapter.

The autobiography is written in a straightforward, vigorous, easy narrative style, and is full of incident and comment. Many of the obstacles with which its author contended, both mechanical and human, are graphically portrayed, particularly his early experiences with the government stamp office and his later ones, in the early days of Bessemer steel, with the ordnance department. In both cases official conservatism, or worse, proved too much for him, but his knighthood came later as a recognition of his services in the prevention of stamp forgeries, while the universal recognition of his achievements with steel must have gone far towards softening the feelings created by the shameful refusal of the ordnance department to acknowledge even that he could make a usable steel. Curiously enough, these are about the only instances of out-and-out failure of serious attempts by the author noted in the whole autobiography, with the exception of the unfortunate experience with the Bessemer Saloon Steamer. This ingenious level-adjusting steamer saloon, designed to prevent seasickness due to the rolling motion of vessels, failed, the inventor declares, through the errors of others; errors, too, which had no relation to the Bessemer invention, and which ruined the enterprise before the invention itself could be given a trial, but not until it had cost the inventor many thousands of pounds sterling. A disinterested observer, however, cannot but feel that this whole attempt must have been a failure after all, or the invention would have been tried again on its merits ere this.

It is, of course, needless to rehearse the story of the life of Sir Henry Bessemer, much less of the steel-making process that bears his name. It may not be out of place, however, to remind the forgetful that the luster of his magnum opus should not blind posterity to the genius which he showed in his early devices for working plumbago, in his type-setting machine, his elaborate plant for the manufacture of bronze, and his improvements in glass making. The supplanting of hand by machine work for the manufacture of bronze powder gave him those "sinews of war" for which he had long striven, in order that he might have the time and money to work out the more important inventions with which his head teemed.

The educational possibilities of such a biography, if made widely available, are so great that it is to be hoped that a low-priced edition will be published in a few years. Some of the plates might be less handsome, but few, if any, would be less useful, if executed on a scale that would permit their insertion, unfolded, in an ordinary octavo volume. Redrawing might, of course, be necessary in some instances. The publishers of the present volume deserve the thanks of the engineering profession for having made Sir Henry Bessemer's Autobiography available in so handsome form, and, considering the expense involved, at so reasonable a price.

ASSOCIATION OF ONTARIO LAND SURVEYORS.—Annual Report and Proceedings at the Thirteenth Annual Meeting since Incorporation, Held at Toronto, Feb. 28, March 1 and 2, 1905. Toronto, Ont.: The Association (Killaly Gamble, Secy.). Paper; 6¼ x 8¾ ins.; pp. 137; illustrated.

Of most general interest are the papers on the "Cost of Constructing Pipe Sewers" at Guelph, Ont. (3 pp.), by James Hutchinson (of Guelph), and "Stadia Topographic Surveying" (9 pp.), by L. B. Stewart, of Toronto; also copies of examination papers for admission to the association, dated February, 1905.

THE CONQUEST OF ARID AMERICA.—By William E. Smythe, Author of "Constructive Democracy," etc. New and revised edition. New York: The Macmillan Co. London: Macmillan & Co., Ltd. Cloth; 5½ x 8¼ ins.; pp. xxvi + 360; illustrated. $1.50, net.

In reviewing the first edition of this book, in our issue of Dec 27, 1900, we said:

> The book deserves, as we presume it will have, a wide reading. It is particularly desirable that it be read extensively in the East; not because the West has nothing to learn from it, for it has great need of taking its teachings to heart, but because it would do much to help the East to a better understanding of the West; not alone the material or the social possibilities of the West as a place for Easterners to go to improve their conditions, but also its aims and ideals as a portion of the American republic.

While the East understands the West and its needs far better to-day than it did five years ago, it still has much to learn on the subject. Nowhere can certain portions of this needed information be gained more readily and pleasantly than in this book—with the single exception of a visit to our vast and otherwise marvelous Western domain.

Mr. Smythe has been connected with the national irrigation movement since 1890, when, as an editorial correspondent of the Omaha "Bee," he began to advocate irrigation in the debatable or semi-arid belt extending through western Nebraska and Kansas. Soon afterwards he established the "Irrigation Age" and took a prominent part in the early National Irrigation Congresses.

In its revised form Mr. Smythe's book brings down to date many of the sociological, political and economic phases of the development of the Far West, dealing with the section as a whole, with separate States, and with colonies. He also outlines the inception and growth of the U. S. Reclamation Service. The book is eminently readable, both in content, style and physical make-up, and it is well illustrated by many half-tone views.

PROCEEDINGS OF THE INCORPORATED ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS.—Vol. XXXI. 1904-1905. Edited by Thomas Cole, Assoc. M. Inst. C. E. (Secretary of the Association). London, Eng.: E. & F. N. Spon, Ltd. New York: Spon & Chamberlain. Cloth; 5½ x 8½ ins.; pp. lxiii. + 451; numerous folding and other plates.

The nearest approach to this association in America is the American Society of Municipal Improvements, but that society has a relatively small membership and meets only once a year, while the foreign one has a large membership, many district meetings and an annual meeting. In the interesting volume before us there are papers on sewage works, refuse destructors, the latter combined with electricity works, the cremation of the human dead, Portland cement, a cattle market, reinforced concrete, highways, tramways, water supply and model building laws, besides the usual descriptions of the municipal works in each of the towns where district meetings were held. In typography, press work and general manufacture the volume is commendable.

CONCRETE AND CONSTRUCTIONAL ENGINEERING.—A Bi-Monthly Journal for Engineers, Architects and Surveyors—Contractors and Builders—and all Workers in Cement, Concrete, Reinforced Concrete, and Constructional Steel. Vol. I. No. 1. March, 1906. (57 Moorgate St., London, E. C., Eng.) Paper; 7 x 9½ ins.; pp. 73; illustrated. Annual, Post Free, 7s. 6d. Single Copies, 1s. net.

The advent of this new journal is interesting as showing the important position reached by reinforced concrete as a structural material even in England, where engineers have been notably slow to appreciate its advantages. For a first issue the work done by the editors is commendable. There are leading articles by a number of English engineers of prominence in the field of work which it is the purpose of the paper to represent, and the contents of the several departments are well chosen.

THE SOURCES OF WATER SUPPLY IN WISCONSIN.—By William Gray Hirchoffer, C. E. Bulletin of the University of Wisconsin, No. 106. Engineering Series, Vol. III. No. 2, pp. 163-275. Madison, Wis.: The University. Paper; 6¼ x 9¾ ins.; pp. 165 to 249; three plates, three diagrams and 21 tables. 50 cts.

After introductory statements regarding the geology and rainfall of the state the author proceeds to describe briefly the sources of the water supplies of Wisconsin, grouped numerous types, as different kinds of well etc. The general quality of the water fr class of supplies is discussed. The study be of value to the state of Wisconsin, and siders wishing information on the subje value of the monograph could have b creased at slight labor and expense by sum ing in tabular form some of the principal tics for each city and village, in alpha order.

A DICTIONARY OF ALTITUDES IN THE STATES.—(Fourth Edition). Compiled by Gannett. Pp. 1072. Bulletin 274, U. S. Survey. Charles D. Walcott, Director. W D. C.: Pub. Doc. Paper; 5¾ x 9 ins.; pp. 10

This valuable reference list has been and extended. It gives by states and local names, both alphabetically arranged, the tion in feet and the authority therefor 50,000 points in the United States, including and mountains as well as cities and towns.

THE BUSINESS OF CONTRACTING.—Reprinted "The Contractor." By Ernest McCullough, A "Municipal Public Works," "Engineering W Towns and Small Cities," etc. Chicago, Ill nical Book Agency (P. O. Box 691). Paper; ins.; pp. 45. 50 cts.

Many useful hints to contractors are gi this little pamphlet. The contractor's staff as a whole, foremen, bidding on lettings, workin and office methods are some of the topics discussed.

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Certain Class Privileges and Dangers.

THE MENACE OF PRIVILEGE.—A Study of the Dangers to the Republic from the Existence of a Favored Class. By Henry George, Jr. New York: The Macmillan Co. London: Macmillan & Co., Ltd. Cloth, 8¼ × 8¼ ins.; pp. 421. $1.50, net.

The word "Privilege," as here used, means advantages or favors, whether enjoyed by private individuals or by corporations. Broadly speaking, it includes the unhindered appropriation to private use of the natural resources of the earth, and particularly lands and their mineral contents; manifold government grants, immunities and exclusion for the benefit of a few to the exclusion of all others. To privilege, in the opinion of the author, a large part of the social, economic and moral ills of the day are due, and without abolition he foresees no relief from conditions absolutely unjust and often quite intolerable.

It is impossible to follow the author through his well-planned and wrought analysis of privilege itself, its "princes" and its victims; the resistance to it offered by labor unions and the dangers incident thereto; the weapons of privilege, including courts, injunctions and bayonets; the corruption which privilege causes in national, state and municipal politics, and its influence over public opinion through its hold on press, university and pulpit; the hand of privilege in centralization of government, in foreign aggression, and upon and as a course of the decay of the civilizations of Athens and of Rome; and, finally, "The Remedy," including the freeing of all "natural opportunities," the cessation of "taxation evils, grants and immunities" and the restoration of the "natural order," which would mean, in short, an entire absence of privilege.

Some idea of the plan and scope of the book and of the attitude of the author towards the whole subject under discussion can be gained by the foregoing outline of the contents of the book. A further idea will be conveyed (to those not aware of the fact, if there be such) by stating that the author is the son of the late Henry George, that brilliant exponent of the single tax, of the negative side of the protective tariff, and of what he conceived to be the rights of the so-called laboring man.

The book before us is one which deserves a wide and careful reading by members of both the privileged and the unprivileged classes, if anyone can tell where the line between the two really lies.

However much or little one may agree with the author regarding the character of Privilege and the remedy for it, few fair-minded persons will question its existence and its menace. It is well for all, even those who belittle the evil and its consequences, to know how Privilege is regarded by one who looks upon it with the eyes of a sympathizer with the classes who are, or who believe they are, its helpless victims. As compared with many of these sympathizers and sufferers, Mr. George may be said to put the case mildly, but his presentation cannot be called impartial. The only notable instance of admission that there can be two sides to any of the phases of his discussion is in connection with some of the excesses of organized labor, and apparently he would have us think that these excesses would disappear if only Privilege, as he conceives it, were abolished.

The great fault of Mr. George's argument, like that of Mr. F. C. Howe in "The City" (see Supplement, Dec. 14, 1905), is its failure to take into account the fundamental moral and mental deficiencies of all mankind, regardless of class. Neither the single tax nor municipal ownership, the two sovereign remedies for municipal ills proposed by Mr. Howe, nor the single tax, and the abolition of tariffs, trusts and all other monopolies, as urged so ably by Mr. George, will eradicate human selfishness and greed, impel all voters to the polls, or when there give them the knowledge and will to vote in accordance with their immediate personal interests, to say nothing of the broader present and future interests of humanity. Until the heart of mankind, *of all classes*, is reformed, the mind enlightened and the will strengthened there will be no abolition of privilege, but at most merely an interchange from one class to another. This is not to say that the menace of privilege should not be pointed out, and every possible remedy for it urged; but let no one imagine that the evil can be rooted out by setting class against class, or by redistributing wealth, or by any amount of legislative or judicial utterance or of abstinence therefrom. Some of the evils of society might be lessened, perhaps greatly lessened, by such means, but without moral and mental, as well as legal and economic, reforms old evils would merely give place to new, and quite possibly to some even worse than those with which society is now burdened.

COMMISSIONER OF HIGHWAYS FOR THE STATE OF MAINE.—First Annual Report, for the Year 1905. (Paul D. Sargent, Commissioner.) Augusta, Me.: Pub. Doc. Paper; 5½ × 9 ins.; pp. 263; illustrated.

General advice and discussion on highway improvement and statistical and descriptive reports from the towns and cities of the state make up the bulk of this volume. The duties of the commissioner are chiefly advisory.

THE PREVENTION OF SENILITY AND A SANITARY OUTLOOK.—By Sir James Crichton-Browne, M. D., LL. D., F. R. S., Lord Chancellor's Visitor in Lunacy. London: Macmillan & Co., Ltd. New York: The Macmillan Co. Cloth; 4¾ × 7½ ins.; pp. 141. 75 cts.

Of these two addresses, delivered about midway in 1905, the first is the most brilliant and of widest interest, partly, it may be presumed, because it was delivered before an audience of more mature and cultured minds than was the second address. After some opening remarks and statistics on the recent increase of longevity, and an able marshalling of evidence to show the remarkable achievements of many men in many lines of work and thought after they had attained the age of 40 or 50 or more, the author declares his belief in a century as a reasonable ideal for human life. He points out that if any such age is to be attained a good start in life must be given, accidents due to violence and communicable diseases warded off, and the wearing effects of worries and anxieties reduced to a minimum. In the address on "The Sanitary Outlook," delivered before a conference of sanitary inspectors, some interesting remarks on the interrelation of heredity and environment, with special stress on the former, were made. The great need of housing reform in Great Britain is discussed at some length. In London 300,000 persons, in families of two or more, live in one-room apartments. In the rural districts also there is a surprisingly large amount of overcrowding and many shocking deficiencies in water supply and the ordinary decencies of household life. The two essays together may be read in an hour or so. The first one in particular is well worth the attention of any thoughtful person or of anyone wishing such entertainment as can be afforded by a brilliant writer who treats not too heavily subjects of some seriousness.

FIRE TESTS OF SOME NEW YORK BUILDING STONES.—By W. E. McCourt. Bulletin 100, Economic Geology 14, New York State Museum. John M. Clarke, Director. Albany, N. Y.: Pub. Doc. Paper; 5¾ × 8¾ ins.; pp. 36; 26 plates and 8 tables. 15 cts.

This bulletin presents as its principal content the records of a series of heat tests and petrographic analysis of a number of typical New York building stones. Heat tests were made of granite, quarries, sandstones, limestones and marbles by subjecting 3-in. cubes to high temperatures in a furnace and then cooling them both gradually and suddenly. Results are given of the individual tests and general conclusions drawn from the tests as a whole. The petrographic analysis cover all the samples tested by heat. Photographs are shown of the test cubes after cooling. The record of tests is prefaced by a discussion of the behaviour of building stones in the Baltimore fire and by a brief account of previous heat tests and of the results obtained from them.

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A PRACTICAL TREATISE ON FOUNDATIONS.—Explaining Fully the Principles involved. Supplemented by Articles on the Use of Concrete in Foundations. By W. M. Patton, C. E., Late Professor of Civil Engineering at the Virginia Polytechnic Institute. Second Edition, Enlarged. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 5¾ × 9¼ ins.; pp. xxviii. + 549; 135 figures, partly in the text. $5.

The publication of the first edition of this book, some thirteen years ago, brought together for the first time the large amount of practical data that had been developed up to that time by American practice in foundation construction. Previous books had been devoted to the presentation of theories and formulas and the explanation of the laws or premises on which they were based. Professor Patton set these aside as sufficiently exploited, and devoted his labor to collecting and classifying methods of work, machines and plant, materials, structural details and costs. In this respect the book was unique at the time of its publication. Since that time many improvements have been made in foundation practice, and in particular concrete, both plain and reinforced, has come to be used to an extent not then dreamed of. To bring the book into line with this advance, it has been enlarged by the addition of some 135 pages of new matter. It is this new matter alone that calls for review here.

The 135 added pages form a continuation of the supplement of the original edition, and the same method of presentation is followed. This, to our mind, is most unfortunate. There was, for example, a splendid opportunity for a careful discussion of the design, adaptability and construction of reinforced concrete foundations. The book meets this opportunity only partially. There is a description of a reinforced concrete chimney foundation, another of a column footing in the same material, and sections describing a number of forms of reinforced concrete piles and pile foundations. Each of these items is interesting and instructive, so far as it goes; but when they are all combined the reader has only an imperfect knowledge of reinforced concrete as it is used today in foundation work. In the same way, the use of metal sheet piling, now so extensively used in foundations, is given inadequate treatment. On the other hand, much space is given to articles on vault light construction, a "system" of reinforced concrete floor construction, the calculation of reinforced concrete beams, concrete filled columns, etc., which hardly command attention in foundation work. To conclude that these supplemental pages do not contain matter of value, would be wrong; there is much of great value in them, but it is the sort of value that rests in a collection of clippings, rather than the sort that comes from a logically arranged and comprehensive discussion based on a careful and complete collection of facts and opinion.

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THE UNITED STATES IN THE TWENTIETH CENTURY.—By Pierre Leroy-Beaulieu. Authorized Translation by H. Addington Bruce. New York and London: Funk & Wagnalls Co. Cloth; 5¼ × 8 ins.; pp. xxvi. + 396. $2, net.

Many a compliment is paid to the industry and character of the people of the United States in this critical digest of the first ten volumes of the Twelfth U. S. Census and of related statistical information. After discussing at some length the geography of the country, the social composition and the general characteristics of the people, their birth and death rates, the author proceeds with a detailed analysis of rural, industrial and commercial America; or in other words, the agricultural, manufacturing and transportation statistics of the United States. The book abounds with comparisions between the United States, Great Britain, Germany and France, and with suggestions and warnings that might well be considered by each of those countries. Our "trusts" will yet be self-destructive, the author thinks.

The translation seems to have been well made, and though essentially statistical the book as a whole may prove interesting to many who are not statistically inclined. Its value, obviously, lies in the fact that it presents in comparatively small compass, and from the viewpoint of a European economist and publicist, a digest of some 50,000 quarto pages of census figures, and of many additional statistics besides. It should not be supposed, however, that the author's knowledge of the United States is based wholly on statistical reports. He takes pains to inform his readers that besides following American periodicals he has spent some time in this country studying conditions at first hand.

RECONNOISSANCE REPORT UPON PROPOSED SYSTEM OF BOLIVIAN RAILWAYS.—By W. L. Sisson, C. E. Cloth; 7 × 11 ins.; pp. 319. Printed by Heitmann & Cornejo, La Paz, Bolivia.

This is a very thorough report upon a preliminary reconnoissance made for the establishment of a system of railways in Bolivia. The report itself does not state for whom this survey was made; but from other information we can state that it was made for a New York banking house which proposed to finance the construction of the railway system. The investigation was begun by Mr. Sisson at La Paz on Dec. 7, 1904, and he traveled during the following three months over 1,600 miles on muleback over some of the most rugged mountain regions in the world. He plans a system of railways with a total extent of 1,000 miles, which he thinks can be built for $41,252,000. Bolivia now has $10,000,000 in its treasury, paid by Brazil on account of the acre territory claims, and this money, Mr. Sisson concludes, would be sufficient to provide for the guarantee and payment of interest on these proposed roads up to the time when they would become self-supporting. Detailed estimates are given of the traffic which each line will be able to command, and it is figured that the net earnings above interest and operating expenses would amount to $3,844,000, or nearly 9½% dividend on the total investment.

Much space is devoted to the mineral and other resources of the regions penetrated; and the book as a whole conveys a very large amount of information respecting a little-known country. It is printed in both English and Spanish. Mr. Sisson is no longer connected with the enterprise, and copies of his report can probably best be obtained through J. E. Zalles, Bolivian Department of Railways, La Paz, Bolivia.

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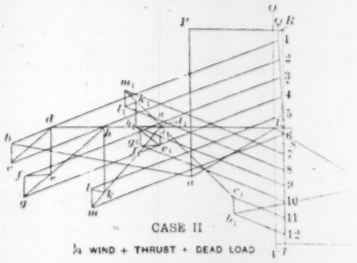

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THE JOURNAL OF THE IRON AND STEEL INSTITUTE.—Vol. LXVIII. No. II. 1905. Edited by Bennett H. Brough, Secretary. London: E. & F. N. Spon, Ltd. New York: Spon & Chamberlain. Cloth; 5½ × 8½ ins.; pp. 879; 30 plates and many text illustrations.

Among the more important papers in this volume we mention: The Department of Iron and Steel Metallurgy at the University of Sheffield; Overheated Steel: Reversible and Irreversible Transformations in Nickel Steel; Wear of Steel Rails on Bridges; and The Influence of Nickel and Carbon on Iron.

ASSOCIATION OF RAILWAY SUPERINTENDENTS OF BRIDGES AND BUILDINGS.—Proceedings of the Fifteenth Annual Convention, Held in Pittsburg, Pa., Oct. 17, 18 and 19, 1905. (S. F. Patterson, Boston & Maine R. R., Concord, N. H., Secretary.) Paper; 6 × 9 ins.; pp. 208; 45 figures in the text and one folding plate.

The principal papers and reports included in this volume are: (1) Construction and maintenance of docks and wharves; (2) concrete building construction; (3) protection of water tanks and water pipes from frost. There are also short reports and discussions upon a variety of other subjects.

THE CATTLE PROBLEM OF ARCHIMEDES.—By Prof. Mansfield Merriman, Lehigh University, South Bethlehem, Pa. (Reprinted from the "Popular Science Monthly," November, 1906). Paper; 6¾ × 9¾ ins.; pp. 660 to 665.

Since the complete solution of this Problem "would require the work of a thousand men for a thousand years," it is unlikely that many of our readers will care to attempt it, but those who wish to know what the problem is and to what extent it has been solved will be repaid for looking up the article in the magazine named, or perchance a stamp sent to Professor Merriman will bring them a copy of the reprint.

Publications Received.

ALTERNA[illegible]G CURRENTS.—Their Theory, Generation and T[illegible]rmation. By Alfred Hay, D. Sc., M. I. E. E. [illegible] York: D. Van Nostrand Co. Cloth; 5½ × 8¼ ins.; [illegible]291; 178 figures in the text. $2.50, net.

BUILDING [illegible]ONSTRUCTION AND SUPERINTENDENCE.—F. E. Kidder, C. E., Ph. D., F. Am. Inst. Archs., [illegible]thor of "The Architects and Builders' Pocket [illegible]." Part III. Trussed Roofs and Roof Trusses. [illegible]ection I. New York: William T. Comstock. [illegible]th; 6½ × 9¾ ins.; pp. 297; 306 figures in the text [illegible]d one plate. $3.

BULLETI[illegible] BUREAU OF THE CENSUS.—S. N. D. North, [illegible]rector. Washington, D. C.: Pub. Doc. Paper; [illegible] 11½ ins.

Nos. 29 to [illegible]33: Census of Manufactures; 1905. Nebraska. [illegible]p. 19. Arizona, Indian Territory, New Mexico [illegible] Oklahoma. Pp. 35. Delaware. Pp. 15. Iowa. [illegible]27. Florida. Pp. 17.

COLORA[illegible]AGRICULTURAL EXPERIMENT STATION. —L. G[illegible]arpenter, Director. Publication of 1903-04. Fort [illegible]ins, Colo.: Colorado Experiment Station. Cloth; [illegible] × 8½ ins.; illustrated.

THE COST OF COMPETITION.—An effort at the Understanding of Familiar Facts. By Sidney A. Reeve. New York: McClure, Phillips & Co. Cloth; 5 × 7¾ ins.; [illegible]ix. + 617; 5 plates and 24 diagrams in the text. $2. net.

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